Learning about ferments from big data

Fermentation is a natural process involving living organisms. Winemakers try to control it as best they can, taking steps to keep the yeast happy and produce the desired wine style. To some extent, however, they still have to leave the yeast alone and wait and see the end result. It's part of the magic and wonder of winemaking but also represents a major source of variation and risk; not only to style and quality, but also to production efficiency. Long ferment times put pressure on tank space and stuck or sluggish ferments can require a huge amount of effort to correct.

The AWRI Ferment Simulator was re-released as a web app this vintage and was trialled by around 50 winemakers. The app uses sophisticated algorithms to predict the outcomes of individual ferments. It also allows winemakers to model the effects of potential corrective actions such as temperature changes or nutrient additions. This helps winemakers make better decisions and gives tighter control of the natural process of fermentation while at the same time providing visual tools for monitoring and recording fermentation performance. This is an exciting new development from a process control perspective, but from a research perspective also provides a valuable new source of data. During vintage 2017 approximately 650 ferments were logged through the Simulator. When aggregated anonymously, this dataset provides new insights into ferment performance at winery scale, under real winery conditions. These insights will then feed into the technical support provided by the AWRI to industry and also guide future research.

Assessing the Simulator's performance

Analysis was carried out to assess the Simulator's performance in predicting ferment outcomes. For each fermentation, an algorithm prediction score was calculated based on the root mean square error (RMSE) between the simulated ferment curve generated based on initial data points and the real Baume data for the full fermentation time. A prediction score < 25 was considered a good fit, and 81% of all ferments met this criterion. The prediction score also provided information about how good the fit was, with lower scores indicating a better fit. A chart of the prediction scores for all ferments tracked this vintage is shown in Figure 1. The median score was 14, which is very encouraging. As the dataset grows with more data from winery-scale fermentations, the model will be developed to further improve this performance.

Understanding which factors affect ferment duration

The ferment durations (time to 0 Baume) for red and white ferments are shown in Figure 2. Red ferment durations were fairly normally distributed around the median of seven days.

White ferments had a median duration of nine days but a much wider, skewed normal distribution, with several going beyond 20 days.

The data were analysed to look for correlations between a number of parameters (grape variety, type of yeast inoculation, DAP addition, initial SO_2 content) and the deviation between the desired length of the ferment as input by the winemaker and the actual duration. This gave the best indication of whether a ferment was running more quickly or slowly than the winemaker's ideal, though it should be noted that ferment duration is not necessarily the

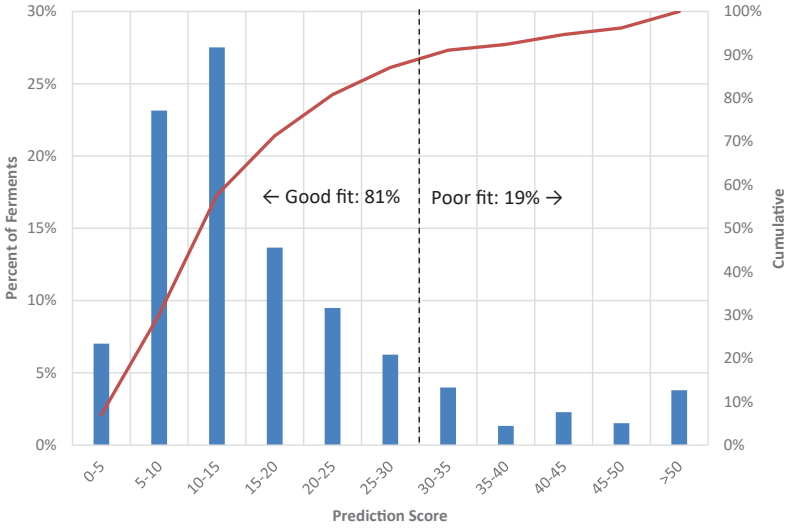

Figure 1. Prediction scores for all ferments from vintage 2017. A prediction score below 25 was classed as a good fit between the simulation and the provided Baume data.

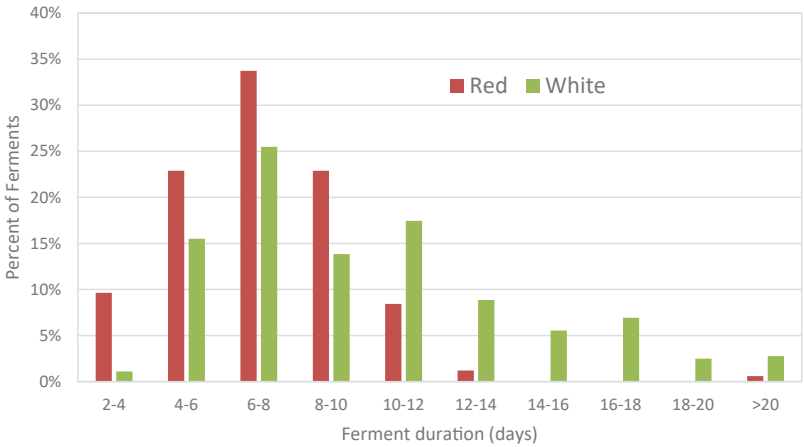

Figure 2. Distribution of ferment duration for red and white ferments.

way all winemakers judge and plan ferments. Others may be guided more by peak Baume drop per day or some other factor. In future, it is hoped to incorporate more flexible targets for ferment performance as options in the Ferment Simulator. It should also be noted that the data shows correlation, but does not necessarily demonstrate the cause of the differences. The relationships observed are intended to provoke thought and further investigation. As the dataset grows, more correlations will come to light and greater confidence may be had in the observations.

The deviation between the desired and actual duration of all ferments was normally distributed around zero deviation. Of the ferments simulated, white ferments had a higher chance of running faster than planned, while red ferments were more likely to be slower than the winemaker's target. A breakdown by the major varieties from the dataset is shown in Figure 3, with Cabernet Sauvignon and Merlot ferments showing greater tendency towards sluggish ferments than other varieties. The timing of the ferment also seemed to play a role in ferment performance, with ferments starting in early to mid-vintage more likely to be faster than planned, and ferments beginning towards the end of vintage more likely to be slower.

A difference was also seen between ferments inoculated with propagated yeast and those inoculated with active dry wine yeast (ADWY) (Figure 4), with ADWY-inoculated ferments having a higher propensity to finish more quickly than the winemaker's target, while propagated yeast ferments had a higher propensity to be slow. Additions of diammonium phosphate (DAP) also had a significant effect, with a reduction in the number of slow ferments

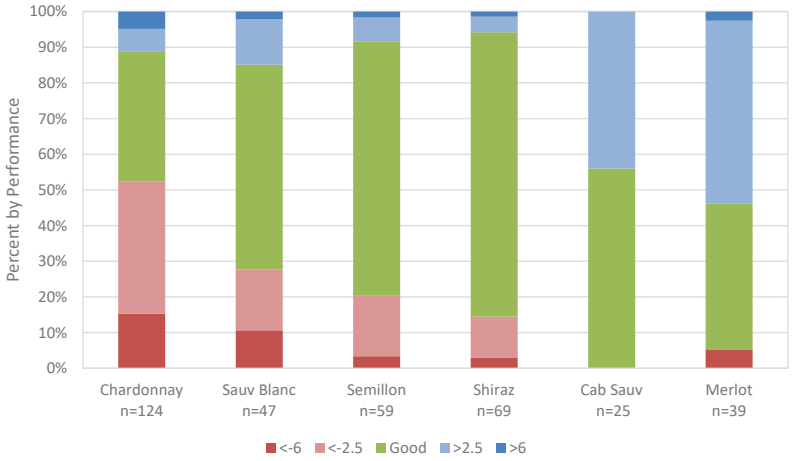

Figure 3. Number of days deviation from desired ferment duration, broken down by grape variety. Good performance was classed as finishing within ±2.5 days of the desired duration (time to 0 Baume). Red indicates a rapid ferment, while blue indicates a sluggish ferment.

seen with a total DAP addition between 100–200 ppm, and an increase in the number of rapid ferments seen with total additions >200 ppm, as might be expected (Figure 5). There was no difference in performance between ferments starting with 0–10 ppm of free SO_2 compared to 10–20 ppm free SO_2 (Figure 6). It was not until free SO_2 was >20 ppm that an influence on ferment performance became apparent.

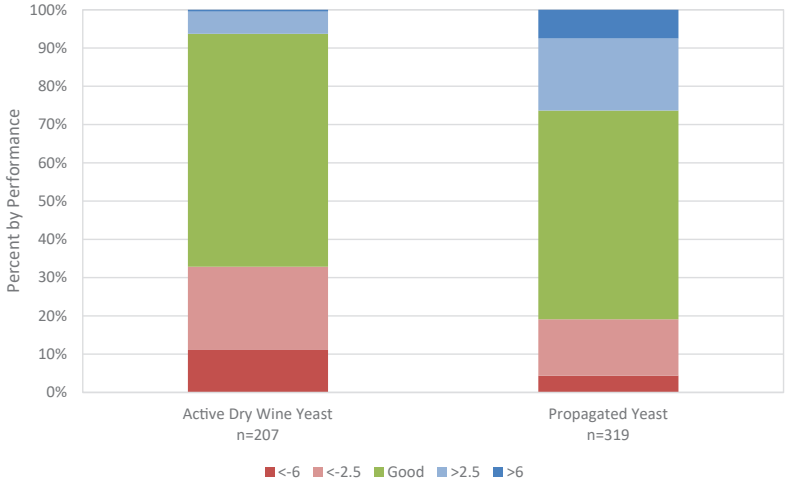

Figure 4. Number of days deviation from desired ferment duration, broken down by inoculation strategy. Good performance was classed as finishing within ±2.5 days of the desired duration (time to 0 Baume). Red indicates a rapid ferment, while blue indicates a sluggish ferment.

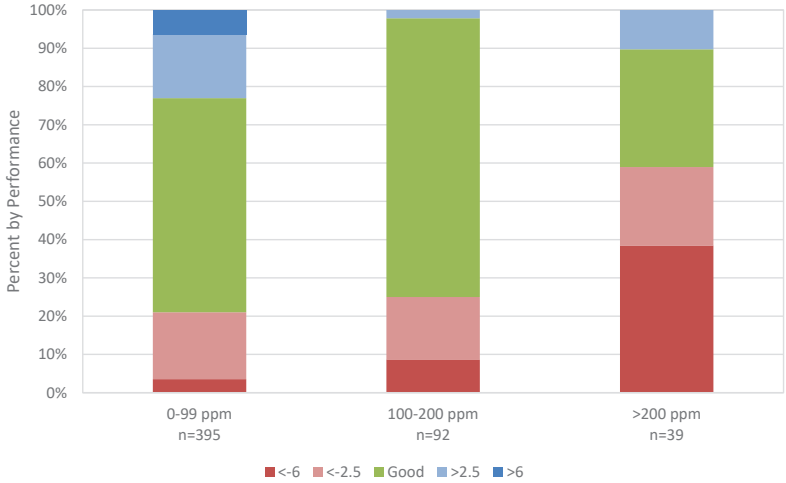

Figure 5. Number of days deviation from desired ferment duration, broken down by total DAP addition. Good performance was classed as finishing within ±2.5 days of the desired duration (time to 0 Baume). Red indicates a rapid ferment, while blue indicates a sluggish ferment.

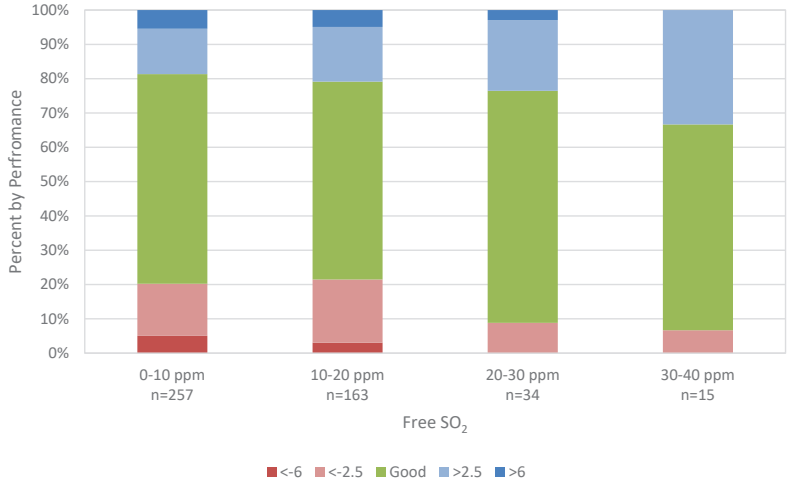

Figure 6. Number of days deviation from desired ferment duration, broken down by free SO_2 concentration in pre-ferment juice analysis. Good performance was classed as finishing within ±2.5 days of the desired duration (time to 0 Baume). Red indicates a rapid ferment, while blue indicates a sluggish ferment.

Conclusions

The results shown highlight some of the ways in which the data from the Ferment Simulator can be used to gain greater insights into ferment performance and potential drivers of fermentation issues. The larger the dataset becomes, the more detailed information will be available. Eventually it should be possible to break down the data by individual varieties in individual regions, with different yeast strains, etc. Australian wineries are encouraged to consider using the Simulator for vintage 2018, both for the immediate predictive benefit in the winery, and as a way of contributing to stronger fermentations for the whole Australian wine industry.

The Ferment Simulator can be accessed by all Australian wineries as a free module of The WineCloud at https://thewinecloud.com.au/.

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