Measuring sugars in wine

Sources of sugar in grapes

Wine is the product of the fermentation of the two main grape sugars: glucose and fructose. These two sugars are by far the most abundant of the grape sugars, at levels around 100 g/L each in must, depending on the fruit and its ripeness. Together they represent around 95% of the total dissolved solids which gives the Baume or Brix reading used to describe grape ripeness. These two sugars usually occur in near equal amounts in must, but climatic and varietal differences can lead to large variations, with glucose to fructose ratios from 0.71 to 1.45 reported. In general, cooler seasons tend to favour glucose production while warmer seasons favour fructose production. The next most abundant grape sugar is sucrose, the familiar cane or table sugar. It is present at levels around 2 to 10 g/L. A range of other polysaccharides including pectins, dextrans and pentose sugars are also found in grapes.

Sugars in wine

Typically wine yeast is only capable of metabolising glucose and fructose. However, yeast produces enzymes that hydrolyse sucrose to its component glucose and fructose units, allowing it to be metabolised. This means that there is rarely more than trace amounts of sucrose left in finished wine (with the exception of wines that have had sucrose deliberately added or where fermentation was stopped before completion). The pentose sugars (predominantly arabinose, xylose, ribose and rhamnose) are not metabolised by yeast and remain in the wine after fermentation at levels of 0.4 to 2 g/L. Thus in wine the most significant sugars likely to be found are traces of unfermented glucose and fructose and small quantities of pentoses.

Yeast has a preference to metabolise glucose over fructose which can lead to a glucose to fructose ratio of 0.25 towards the end of ferment. The degree of this imbalance is strongly dependent on yeast type and ferment conditions, and can be implicated in slow and stuck ferments. Fructose tastes twice as sweet as glucose (1.73 compared to 0.74 on the relative sweetness scale where sucrose is 1). This explains why wines where fermentation has stopped before reaching dryness (and therefore likely contain more fructose than glucose) appear sweeter than those which have had grape concentrate or juice added (which contains equal amounts of glucose and fructose). The pentoses, the next major sugars, only have a relative sweetness of 0.4 and as such contribute very little to perceived sweetness.

Which sugars should be analysed in wine?

There are three major drivers for measuring sugars in wine:

1) to determine that the fermentable sugars have been exhausted and that further fermentation is unlikely
2) to determine the sugar available to influence the sweetness of the wine
3) for the purposes of labelling wines as 'dry', 'semi-dry' or 'sweet' under certain regulatory environments.

It makes sense to tailor the sugar analysis methods used in wine production to meet these three aims.

For 1) it is the fermentable sugars (glucose and fructose) that are relevant for analysis, as these are the sugars that yeast can metabolise.

For both 2) and 3) the key outcome is to understand the perceived sweetness of the final wine. In this case, it is again the glucose and fructose that need to be measured because they are the sugars that make the most significant contributions to wine sweetness. These can be present in above trace levels in cases where the ferment has been stopped early or if a wine has been sweetened by the addition of grape juice or concentrate. If sucrose has been added to wine (this is not permitted in Australia for still wines), the natural acid hydrolysis of wine conditions sees it slowly converted to its glucose and fructose subunits. As such, the practical methods for its measurement require its conversion to glucose and fructose before analysis. The other sugars in wine, such as the pentoses, contribute relatively little to the final perceived sweetness of the product because of their much lower intrinsic sweetness. Their inclusion in any analysis is likely to give a false indication of the wine's sweetness.

So, no matter which of the main three drivers for measuring sugars is applicable, it is the glucose and fructose concentration that is relevant. This was reflected in the OIV resolution ECO 3 /2003 which included a footnote: *"sugar content is determined by the 'glucose + fructose' method of analysis described in the International Compendium of Methods of Analysis."*

Methods for sugar analysis

Modern analytical methods concentrate on the direct analysis of glucose and fructose using a range of techniques including enzymatic analysis and high performance liquid chromatography (HPLC). These techniques produce results that are highly accurate and precise with little interference from other wine components. The methods and technology needed for accurate glucose and fructose analysis are widely available and accessible at low cost for even small laboratories.

Before the advent of these techniques, however, sugar analysis was conducted using methods that rely on the capacity of many sugars to reduce an alkaline solution of copper (II) ions. This led to the term 'reducing sugars' once commonly used to describe wine sugar analysis. Methodologies based on these techniques are not specific to glucose and fructose, but instead also detect the non-relevant pentose sugars, resulting in artificially high results. They also suffer from significant interference from other wine components, requiring a range of pre-analysis steps which introduce further errors into the analysis. This results in sugar measurements that are generally between 0 and 3 g/L higher than those determined by the use of glucose and fructose analysis, and occasionally much higher. Such methods are also generally much less precise, with associated standard errors usually double those seen for the equivalent direct glucose and fructose determinations.

Conclusions

The use of 'reducing sugar' methods can result in the mislabelling of wines and incorrect advice to the final consumer based on the artificially high results. Indirectly these methods can also lead to inaccuracies in other analytical determinations such as 'sugar free extract', which is sometimes used to try and determine if a wine has been adulterated by the addition of water. An artificially high result introduced by 'reducing sugar' methods can lead to wines being determined as non-compliant with regulations based on this measure.

Thus, whether a sugar measurement is carried out to make sure a fermentation is complete, for labelling/regulatory purposes or to understand the likely sweetness of the product, direct measurement of glucose and fructose is the most accurate and relevant option.

One point to bear in mind is that the regulatory authorities in some countries still use outdated reducing sugar methods as part of their regulatory framework and this can lead to issues with interpretation of results. In such cases, care must be taken to ensure an appropriate method is used, not for scientific or practical reasons, but simply to ensure compliance. International efforts are underway to encourage all wine-importing countries to standardise regulatory frameworks on glucose and fructose sugar analysis methods.

Further reading

OIV Resolution ECO3/2003 – http://www.oiv.int/.

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