

RESOLUTION OENO 11/2006

WHOLE DETERMINATION OF GLUCOSE, FRUCTOSE AND SACCHAROSE CONTENT IN MUSTS AND WINES BY DIFFERENTIAL pH-METRY

THE GENERAL ASSEMBLY

CONSIDERING Article 2 paragraph 2 iv of the Agreement of April 3, 2001 establishing the International Organization of Vine and Wine,

UPON THE PROPOSAL of the Sub-commission of Methods of Analysis and Appraisal of Wine,

DECIDES to complete Annex A of the Compendium of International Methods of Analysis of Wine and Must with the following method and to adopt it in the form of a type IV method:

Title	Method
Whole determination of glucose, fructose and saccharose content in wines by differential pH-metry	Type IV

1. SCOPE

This method is applicable to the analysis of glucose and fructose in wines between 0 and 270 g/L.

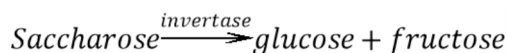
This quantification is different from glucose and fructose quantification by its differential pH-metry which can not be substituted.

2. PRINCIPLE

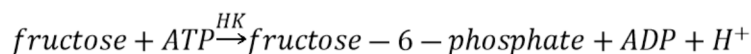
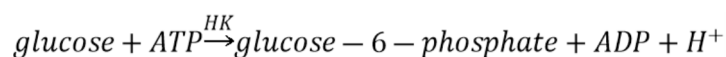
The determination by differential pH-metry of glucose, fructose and saccharose content consists in the preliminary hydrolysis of saccharose by invertase, followed by phosphorylation of the glucose and fructose by hexokinase. The H⁺ ions generated stoichiometrically in relation to the quantities of glucose and fructose are then quantified.

3. REACTIONS

Possible traces of saccharose are hydrolysed by invertase (EC 3.2.1.26)



The glucose and fructose initially or consecutively present to invertase action are phosphorylated by adenosine triphosphate (ATP) during an enzymatic reaction catalysed by hexokinase (HK) (EC. 2.7.1.1)



4. REAGENTS

- 4.1. Demineralised Water (18 M Ω) or bi-distilled
- 4.2. 2-Amino-2-(hydroxymethyl)propane-1,3-diol (TRIS) purity \square 99%
- 4.3. Disodic adenosine triphosphate (ATP, 2Na) purity \square 99%
- 4.4. Trisodium phosphate with twelve water molecules ($\text{Na}_3\text{PO}_4 \cdot 12\text{H}_2\text{O}$)
purity \square 99%
- 4.5. Sodium hydroxide (NaOH) purity \square 98%
- 4.6. Magnesium chloride with six water molecules ($\text{MgCl}_2 \cdot 6\text{H}_2\text{O}$) purity \square 99%
- 4.7. Triton X 100
- 4.8. Potassium chloride (KCl) purity \square 99%
- 4.9. 2-Bromo-2-nitropropane-1,3-diol (Bronopol) ($\text{C}_3\text{H}_6\text{BrNO}_4$)
- 4.10. Invertase (EC 3.2.1.26) 1 mg \square 500 U (ex Sigma ref I-4504)
- 4.11. Hexokinase (EC. 2.7.1.1) 1 mg \square 145 U (e.g. Hofmann La Roche, Mannheim, Germany ref. Hexo-70-1351)
- 4.12. Glycerol purity \square 98%
- 4.13. Saccharose purity \square 99%
- 4.14. Reagent buffer pH 8.0 commercial (ex. DIFFCHAMB GEN 644) or prepared

according to the following method:

In a graduated 100-ml flask (5.2) pour roughly 70 ml (5.3) of water (4.1), and continuously stir (5.5). Add 0.242 g \pm 0.001 g (5.4) of TRIS (4.2), 0.787 g \pm 0.001 g (5.4) of ATP (4.3), 0.494 g \pm 0.001 g (5.4) of sodium phosphate (4.4), 0.009 mg \pm 0.001 g (5.4) of sodium hydroxide (4.5), 0.203 g \pm 0.001 g (5.4) of magnesium chloride (4.6), 2.000 \pm 0.001 g (5.4) of Triton X 100 (4.7), 0.820 g \pm 0.001 g (5.4) of potassium chloride (4.8) and 0.010 \pm 0.001 g (4.9) of bronopol. Adjust to volume with water (4.1). The final pH must be 8.0 \pm 0.1 (5.6), otherwise adjust it with sodium hydroxide or hydrochloric acid. The buffer thus prepared is stable for two months at 4°C.

4.15. Enzyme solution commercial or prepared according to the following method:

Using a graduated pipette (5.7) place 5 ml of glycerol (4.11) into a graduated 10-ml flask, adjust to volume with water (4.1) and homogenize. Dissolve 300 mg \pm 1 mg (5.4) of invertase (4.10) 10 mg \pm 1 mg (5.4) of hexokinase (4.11) in 3 mL of glycerol solution. Enzyme solution activity must be 50 000 U \pm 100 U per ml for invertase and 480 U \pm 50 U for hexokinase. The enzyme solution is stable for 6 months at 4°C.

4.16. PREPARATION OF REFERENCE SOLUTION

Place 17,100 g \pm 0.01 g (5.4) of saccharose (4.13) (desiccated 12 hours beforehand at 40 °C until constant weight), 0.745 g \pm 0.001 g (5.4) of potassium chloride (4.8) and 0.010 g \pm 0.001 g (5.4) of bronopol in a graduated 100-ml flask (5.2). Add water (4.1). Fully homogenize (5.5). Adjust to volume with water (4.1) after removing the magnetic bar. The final concentration is 171 g/L of saccharose. The solution is stable for 6 months at 4°C.

5. APPARATUS

5.1. Differential pH-metry apparatus (EUROCHEM CL 10 plus, Microlab EFA or equivalent) see appendix A

5.2. Graduated 100-ml flask, class A

5.3. Graduated 100-ml test-tube with foot

5.4. Precision balance to weigh within 1 mg

5.5. Magnetic stirrer and magnetic Teflon bar

5.6. pH-meter

5.7. Graduated 3-mL, 5-mL pipette, class A

5.8. Graduated 10-ml flask, class A

5.9. Automatic syringe pipettes, 25 and 50 μ L

6. PREPARATION OF SAMPLES

Samples must not contain excessive suspended matter. If this occurs, the solution centrifuge and filter. Sparkling wines must be degassed

7. PROCEDURE

The operator must respect the instructions for use of the equipment (5.1). Before any use, the instrument must be stabilized in temperature. The circuits must be rinsed with the buffer solution (4.14) after cleaning, if required.

7.1. Determination of the blank (determination of the enzyme signal)

Fill the electrode compartments (EL₁ and EL₂) of the differential pH-meter (5.1) with the buffer solution (4.14); the potential difference between the two electrodes (D₁) must range between ± 150 mV;

Add 32 μ L of enzyme solution (4.15) to the reaction vessel (using the micropipette 5.9 or the preparer) and fill electrode EL₂;

Measure the potential difference (D₂) between the two electrodes;

Calculate the difference in pH, ΔpH_0 for the blank using the following formula:

$$\bullet \Delta\text{pH}_0 = D_2 - D_1$$

where

ΔpH_0 = the difference in pH between two measurements for the blank;

D₁ = the value of the difference in pH between the two electrodes filled with the buffer solution;

D₂ = the value of the difference in pH between the two electrodes, one of which is filled with the buffer solution and the other with the buffer solution and enzyme solution.

The value of ΔpH_0 is used to check the state of the electrodes during titration as well as their possible drift over time; it must lie between -30 and 0 mV and ± 1.5 mV between two consecutive readings. If not, check the quality of the buffer pH and the cleanliness of the hydraulic system and electrodes, clean if necessary and then repeat the blank.

7.2. Calibration

Fill the electrode compartments (EL₁ and EL₂) with the buffer solution (4.14);

Add 10 µL (with the micropipette 5.9 or the preparer) of the standard saccharose solution (5) to the reaction vessel;

Fill the electrodes EL₁ and EL₂ with the buffer + standard solution;

Measure the potential difference (D₃) between the two electrodes;

Add 32 µL of enzyme solution (4.15) and fill electrode EL₂ with the buffer + standard solution + enzyme;

After the time necessary for the enzymatic reaction, measure the potential difference (D₄) between the two electrodes;

Calculate the difference in pH, ΔpH_c for the calibration sample using the following formula:

$$\bullet \Delta\text{pH}_c = (D_4 - D_3) - \Delta\text{pH}_o$$

where

ΔpH_c = the difference between two measurements D₃ and D₄ for the calibration sample minus the difference obtained for the blank;

D₃ = the value of the difference in pH between the two electrodes filled with the reference buffer/solution mixture;

D₄ = the value of the difference in pH between the two electrodes, one of which is filled with the reference buffer/solution and the other with the buffer/ enzyme / reference solution.

Calculate the slope of the calibration line:

$$\bullet s = C_u / \Delta\text{pH}_c$$

where

C_u is the concentration of saccharose in the standard solution expressed in g/L.

Check the validity of the calibration by analysing 10 µL of standard solution (ML) of saccharose (5) according to the procedure (8.3). The result must range between \pm 2% of the reference value. If not, repeat the calibration procedure.

7.3. Quantification

Fill the electrode compartments (EL₁ and EL₂) with the buffer solution (4.14)

Add 10 µL (with the micropipette 5.9 or the preparer) of the sample solution to the reaction vessel;

Fill electrodes EL₁ and EL₂ with the buffer + sample mixture;

Measure the potential difference (D₅) between the two electrodes;

Add 32 µL of the enzyme solution (4.15) and fill electrode EL₂ with the buffer mixture + sample + enzyme;

Measure the potential difference (D₆) between the two electrodes;

Calculate the quantity of aqueous solution in the sample using the following formula:

$$w = s \cdot [(D_6 - D_5) - \Delta pH_0]$$

where

w = the quantity of aqueous solution in the sample (in g/L);

S is the slope determined by the calibration line;

ΔpH_0 = the difference in pH between two measurements for the blank;

D₅ = the value of the difference in pH between the two electrodes filled with the sample/ reference solution;

D₆ = the value of the difference in pH between the two electrodes, one of which is filled with the buffer/sample and the other with the buffer/ sample /enzyme.

8. EXPRESSION OF RESULTS

The results are expressed in g/L of glucose with one significant figure after the decimal point.

9. CHARACTERISTICS OF THE ANALYSIS

Due to the hydrolysis of saccharose in wines and musts, it is not possible to organise an inter-laboratory analysis according to the OIV protocol.

Inter-laboratory studies of this method demonstrate that for saccharose, the linearity between 0 and 250 g/l, a detection limit of 0.2 g/l, a quantification limit of 0.6 g/l, repeatability of $0.0837x - 0.0249$ g/l and reproducibility of $0.0935x - 0.073$ g/l

(saccharose content).

10. QUALITY CONTROL

Quality controls can be carried out with certified reference materials, wines whose characteristics have been determined by consensus, or loaded wines regularly used in analytical series, and by following the related control charts.

Appendix A

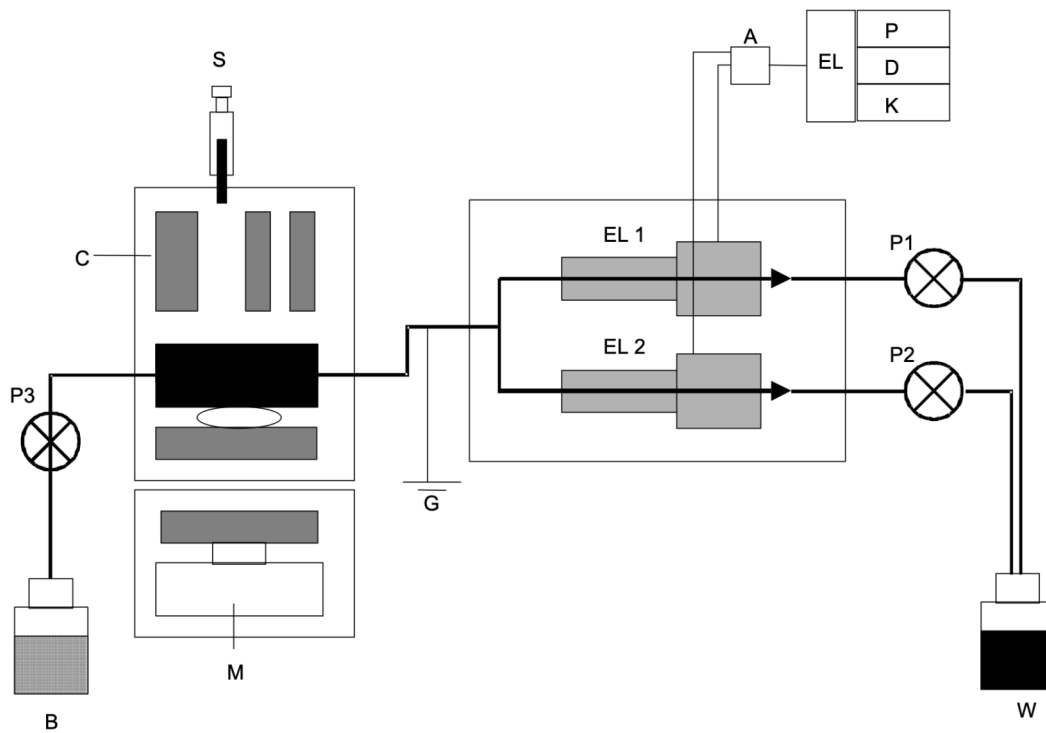


Diagram of the differential pH-metry apparatus

A: differential amplifier; B: buffer solution; C: mixing chamber;
 D: indicator; EL₁ and EL₂ capillary electrodes; EL: electronics; G: ground; K: keyboard;
 M: magnetic stirrer; P: printer; P₁ to P₃: peristaltic pumps; S: injection syringe for the
 sample and enzyme; W: waste.

Appendix B

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