RESOLUTION OENO 6/2007

CODEX - CINNAMOYL ESTERASE

THE GENERAL ASSEMBLY

IN VIEW of article 2, paragraph 2 IV of the agreement dated 3rd April 2001, by which the International Organization of Vine and Wine was founded,

FOLLOWING a proposal made by the Sub-Commission of Methods of Analysis and Appraisal of Wine and the Specification of Oenological Products expert group,

HAS HEREBY DECIDED to add the following method to the international Oenological Codex:

MEASUREMENT OF CINNAMOYL ESTERASE ACTIVITY

This activity which can be present in the enzymatic extracts of Aspergillus Niger must be the weakest possible because the cinnamic acids that it releases are liable to be transformed thereafter by micro-organisms contaminating the must or the wine into nauseous "volatile phenols" (4-ethylphenol, 4-ethylgaïacol, 4-vinylphenol, 4-vinylgaïacol etc.)

Since we have no principal precursor, para-coumaroyltartric acid, two methods are proposed; the first uses the chlorogenase activity of Aspergillus Niger i.e. the hydrolysis of chlorogenic acid (caffeoylquinic); this requires the implementation of conventional enzymatic measuring apparatus. This activity is sometimes presented as a depsidase activity (i.e. the hydrolysis of m-digallic acid)

The second relates to the hydrolysis of ethyl cinnamate, the content of which is measured by gas chromatography.

The two methods were compared, and give results of the same order of magnitude.

A. CHLOROGENATE HYDROLASE or CHLOROGENASE (EC. 3.1.1.42 – CAS no. 74082-59-0)

1. Measurement of cinnamoyl esterase activity (CE)

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2. Scope

The conditions and method were developed for application to commercial enzymatic preparations as found on the oenological market.

3. Principle

Cinnamoyl esterase degrades chlorogenic acid releasing caffeic acid. The reduction in measured absorbance at 350 nm linked to the disappearance of this substrate can be used to quantify the cinnamoyl esterase activity.

An enzymatic unit is defined as being the quantity of enzyme enabling a drop in the absorbance of 1 unit at pH 6.5 and 30°C.

4. Apparatus

4.1. water bath at 30°C

4.2. water bath at 100°C

4.3. 2 liter graduated flask

4.4. 125-mL Erlenmeyer flask

4.5. 100-mL graduated flask

4.6. 1000-mL graduated flask

4.7. chronometer

4.8. 100-µL precision syringe

4.9. 1000-µL precision syringe

4.10. 5000-µL precision syringe

4.11. graduated 5-mL straight pipette

4.12. pH-meter

4.13. spectrophotometer

4.14. 15 mL glass screw-top test tubes

4.15. metal rack for 15-mL test tubes

4.16. cuvets with a 1-cm optical path length, for single use, for spectrophotometer, for measurement in the UV spectrum

4.17. stirrer of the Vortex type

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5. Products

5.1. methanol (Analytical Reagent Rank – CH_3OH - PM = 32.04 g/mole)

5.2. sodium dihydrogenophosphate (NaH2PO4.2H2O 99% pure - PM = 156.01 g/mole)

5.3. sodium hydroxide (NaOH 99% pure - PM = 40 g/mole)

5.4. chlorogenic acid (95% pure - PM = 354.30 g/mole)

5.5. distilled water

5.6. commercial enzymatic preparation for analysis

6. Solutions

6.1. Methanol at 80% (v/v)

Introduce 100 mL of methanol (5.1) into a 125-mL Erlenmeyer flask (4.4) to which 25 mL of distilled water (5.5) have been added.

6.2. Sodium hydroxide solution at 9M:

Introduce 360g of sodium hydroxide (5.3) into a 1000-mL graduated flask (4.6) and make up with distilled water (5.5).

6.3. Phosphate buffer 0.1M (pH 6.5)

Introduce 31.5 g of sodium dihydrogenophosphate (5.2) into a 2-liter graduated flask (4.3) to which 1.8 litres distilled water (5.5) have been added.

Adjust the pH to 6.5 using the sodium hydroxide solution (6.2) and a pH-meter (4.11). Then adjust the volume with 2 litres with distilled water (5.5).

6.4. Chlorogenic acid solution at 0.06% (p/v)

Dissolve 0.06 g of chlorogenic acid (5.4) in a 100-mL graduated flask (4.5) to which the phosphate buffer (6.3) has been added up to the gauge line.

7. Preparation of the sample

It is important to homogenise the enzymatic preparation before sampling, by upturning the container for example. The enzymatic solution and the blanks will have to be prepared extemporaneously.

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7.1. Enzymatic solution at 10 g/L

Place 1g of commercial preparation (5.6) in a 100-mL graduated flask (4.5), make up with the phosphate buffer (6.3), and stir (4.17) in order to obtain a homogeneous mixture.

7.2. White denatured by heating

Place 10 mL of the enzymatic solution at 10 g/L(7.1) in a 15-mL test tube (4.13) and immerse the tube for 5 minutes in the water bath at 100°C (4.2).

8. Procedure

8.1. Enzymatic reaction: The test tubes are produced at least in duplicate.

In 4 x 15-mL test tubes (4.13) numbered from 1 to 4, placed in a rack (4.14) introduce
100 µL of the enzymatic solution at 10 g/L(7.1), using the precision syringe (4.8),
500 µL of the chlorogenic acid solution (6.4),, start the chronometer (4.7).
After shaking (4.17), the test tubes are placed in the water bath at 30°C (4.1)

- for 120 min. for test tube no.1
- for 240 min. for test tube no.2
- for 330 min. for test tube no.3
- for 400 min. for test tube no.4

The reaction is stopped by adding 5 mL of methanol at 80% (6.1) using a straight pipette (4.11) in each of the numbered tube 1 to 4, immediately after they have been removed from the water bath at 30°C. The tubes are then shaken.

8.2. Proportioning of the released substances (caffeic acid)

The reactional medium (8.1) is placed in a cuvet with a 1-cm optical path length (4.16). Immediately measure the absorbance at 350 Nm, using a spectrophotometer (4.13). The measurement is to be compared with a blank of methanol 80% pure (6.1).

9. Calculations

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9.1. Determining the kinetics

In general, calculating the enzymatic activity can only be done when the substrate and the enzyme are not in limiting quantities. This therefore refers to the ascending phase of the kinetic representation: the enzymatic activity is linear in time. Otherwise, the activity would be underestimated (Figure 1).

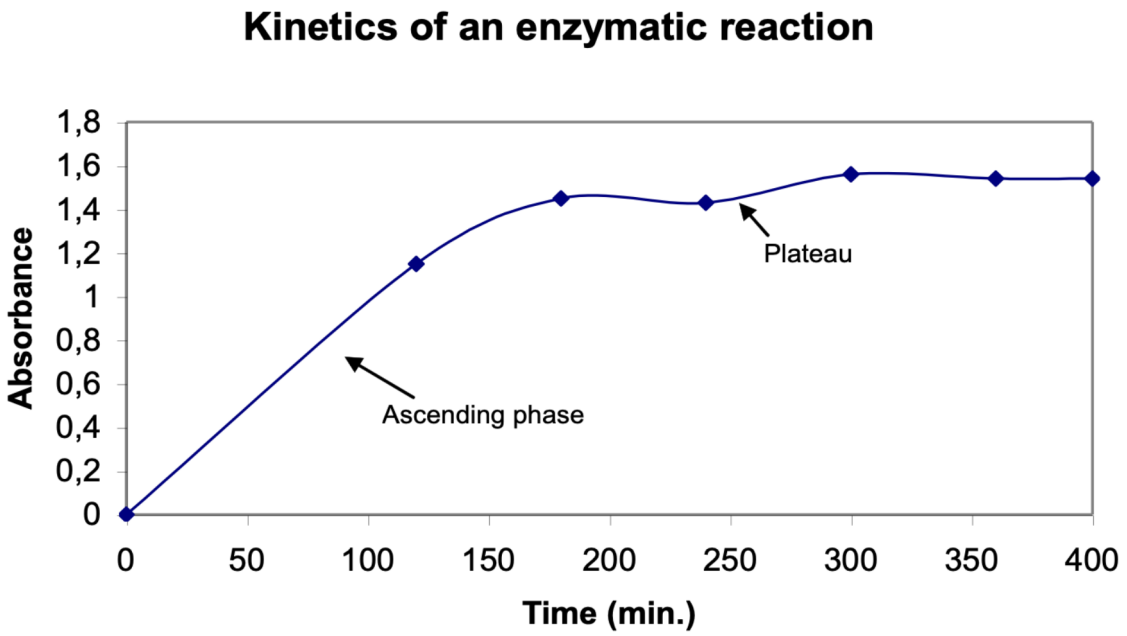


Figure 1: Kinetics of an enzymatic reaction

The kinetics are determined over 400 minutes. The activity concerned is measured at T=120 min T=180 min, T=240 min, T=300 min T=360 min T=400 min.

After determining the kinetics of the enzymatic reaction, plot the curve for the variation in absorbance in relation to reaction time. The absorbance corresponds to the difference between the absorbance at time T of the enzymatic preparation and that of the corresponding blank. Then calculate the equation (1) of the straight regression line, taking into account only the points of the ascending phase (see figure 1).

9.2 Calculation of the enzymatic activity

The cinnamoyl esterase activity is calculated based on the reduction in absorbance per hour since this activity is very weak in the preparations. The calculation formula is

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as follows

$$Activity\ in\ U/g = 1000 \times ((DO_0 - DO_T)/T)/(V \times C)$$

DO_0: Value of the absorbance of the blank

DO_T: Value of the absorbance at time T (hour)

V: quantity of enzymatic solution introduced (µL), in this case 100 µL

C: concentration of the enzymatic solution (g/L), in this case 10 g/L

B. HYDROLYSIS OF ETHYL CINNAMATE

1. Principle

Cinnamoyl esterase hydrolysises ethyl cinnamate. The reduction in this ester measured by gas chromatography can be used to quantify the cinnamoyl esterase activity.

2. Apparatus

2.1. Gas phase chromatograph with a flame ionisation detector or mass spectrometry equipped with a capillary tube of the Carbowax 20 M type 50 m x 0.2 mm x 0.2 µm phase thickness

2.2. pH-meter

2.3. Magnetic stirrer and stirrer bars

2.4. Laboratory glassware (5-mL precision pipettes, conical flasks, 50-mL and 100-mL graduated flasks, 10-mL, 60-mL, 150-mL laboratory glass bottles etc.)

2.5. Pasteur pipettes

2.6 200-µL, 50-µL and 10-µL precision syringes

2.7. Drying oven at 25°C

2.8. Precision balance to within 0.1 mg/l

3. Products

3.1. Methanol (Analytical Reagent Rank – CH_3OH - PM = 32.04 g/mole) 3.2 Citric acid 99% pure

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3.3. Sodium hydroxide (NacOH 99% pure - PM = 40 g/mole)

3.4. Ethyl cinnamate (99% pure - PM = 176 g/mole)

3.5. Distilled or permuted water

3.6. Commercial enzymatic preparation for analysis

3.7. Pure ethanol 99% vol.

3.8. Diethylic ether 99% pure.

3.9. Pure Dodecanol

4. Solutions

4.1. Ethanol at 12% (v/v)

Introduce 12 mL of ethanol (3.7) into a 100-mL graduated flask (2.3) make up to volume with distilled water (3.5).

4.2. Sodium hydroxide solution 4 M

Introduce 16 g of pure sodium hydroxide into a 100-mL graduated flask; make up with distilled water; stir until dissolution.

4.3. Citrate buffer at pH 6.5

Introduce 0.05 g of citric acid (3.2) into a 150 mL bottle (2.3), add 100 mL of ethanol to 12% vol. (4.1) dissolve using a magnetic stirrer. Place under magnetic stirring in the presence of the electrode of the pH-meter (2.2) bring to pH 6.5 by adding the sodium hydroxide 4 M drop by drop (4.2).

4.4. Stock solution of ethyl cinnamate at 500 mg/L

Using a precision syringe (2.5) place 50 µL of ethyl cinnamate (3.4) in a 100-mL graduated flask containing a little pure ethanol (3.7) make up to the gauge line with pure ethanol (3.7); homogenise

4.5. Ethyl cinnamate solution at 25 mg/Lin the citrate buffer

In a 100-mL graduated flask, place 5 mL of stock solution of ethyl cinnamate at 500 mg/L(4.4) measured with a precision pipette (2.3); make up to 100 mL with the citrate buffer at pH 6.5 vol. (4.3). Homogenise.

Note: a more concentrated ethyl cinnamate solution must not be prepared because the ester is liable to be partially insoluble.

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4.6. Dodecanol solution at 0.5 g/L(internal standard)

Using a precision syringe (2.6) place 50 µL of pure dodecanol (3.9) in a 100-mL graduated flask containing a little pure ethanol (3.7); make up the gauge line with pure ethanol (3.7); homogenise.

5. Preparation of the sample

It is important to homogenise the enzymatic preparation before sampling, by upturning the container for example.

6. Procedure

6.1. Enzymatic reaction: In a 60-mL laboratory flask, place 50 mL of ethyl cinnamate solution at 25 mg/L(4.5) add approximately 100 mg of the commercial enzymatic preparation to be analysed (3.6) weighed with precision (2.7), i.e. weight P.

After stirring (2.2), the bottle is plugged and left on the laboratory bench or if possible in a drying oven at 25°C (2.6)

6.2. A sample of 200 µL is taken with a precision syringe (2.5) after 3 hours, 24 hours, 72 hours.

6.3. The reaction is stopped by adding the sample (6.2) of 200 µL in a 10-mL flask containing 0.5 mL of methanol (3.1) and 1 mL of ether (3.8)

6.4. Addition of the internal standard

In the preparation (6.3), using a precision syringe (2.5) add 50 µL of dodecanol to 500 mg/L(4.6); homogenise.

6.5. Blank

Proceed as in 6.3 and 6.4 without adding the 200 µL of the sample from the enzymatic reaction (6.2)

6.6. Reference solution

Proceed as in 6.3 and 6.4 by placing in the bottle (6.3) 200 µL of ethyl cinnamate solution at 25 mg/L(4.5) instead of the sample of enzymatic reaction (6.2)

6.7. Chromatography

6.7.1. Inject 2 µL of the blank (6.5) into the chromatograph to locate the internal standard. Start the temperature programmer and the data acquisition.

6.7.2. Inject 2 µL of reference solution to locate the ethyl cinnamate (ec) and the internal standard (is); measure their respective surface areas Sec0 Sis0

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6.7.3. Under the same conditions as 6.7.2 inject the samples (6.4) after 3 hours, after 24 hours and after 72 hours, i.e. the respective surface areas of residual ethyl cinnamate and internal standard S3 and Sis3; S24 Sis24, S72 Sis72.

Determine the quantity of residual ethyl cinnamate for each sample; for example for 72 hours.

$$EC72 = \frac{25 \times Sis0}{SEC0} \times \frac{SCE\ 72}{Sis72}$$

$$EC\ consumed\ in\ 72\ hours = 25 - EC\ 72$$

Cinnamyl esterase activity in mg of hydrolysed ethyl cinnamate per hour and g of enzymatic preparation

$$EC\ activity\ in\ EC\ mg/g\ enzyle/hour = \frac{25 \times EC\ 72 \times\ 1000}{P \times 25 \times 72}$$

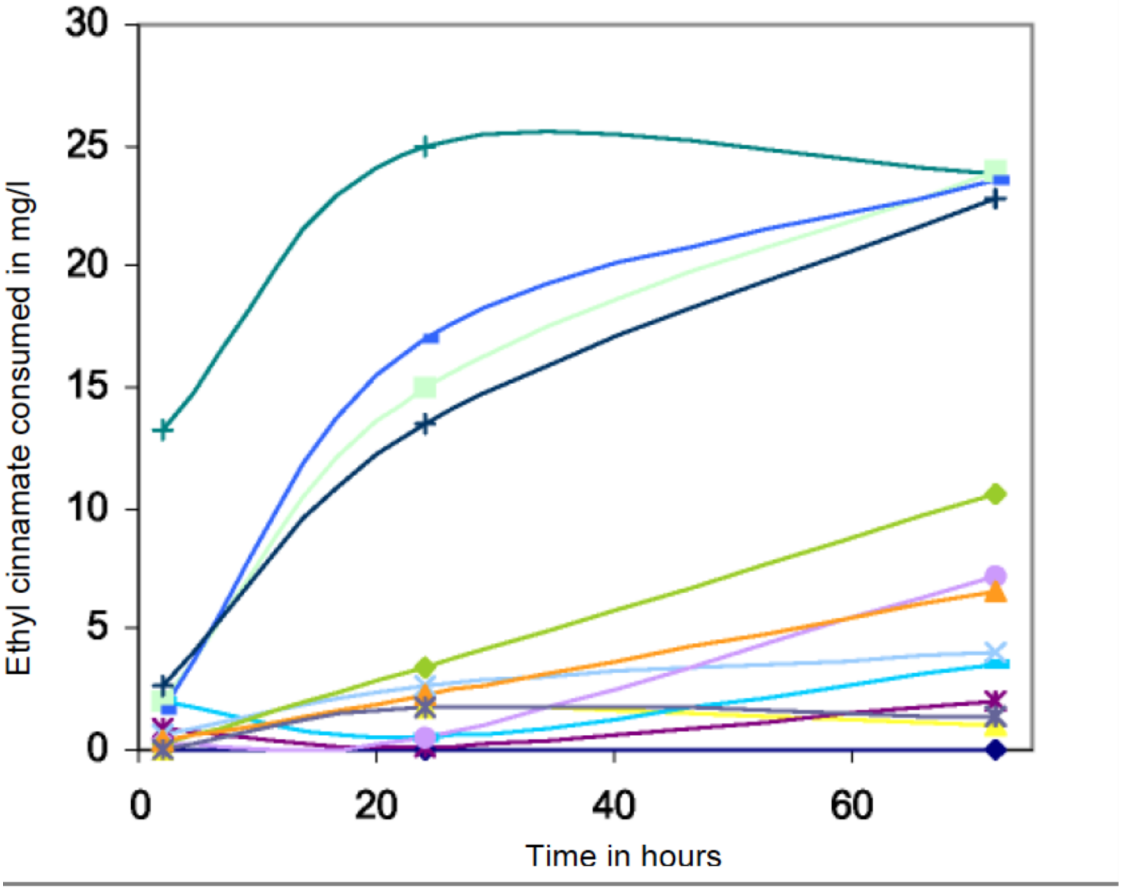
P = weight of enzyme added in the preparation (6.1) in mg/l.

Comments: The method is freely adapted from Barbe (1995).

The reaction taking place at pH 6.5 is much more complete than with the pH in the wine where it is approximately 10 times slower; therefore, if after 72 Hours, only a few mg of ethyl cinnamate have been degraded, the EC activity in the wine can be considered negligible.

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Examples of cinnamoyl esterase activities measured at pH 6.5, of commercial enzymatic preparations.

7. Bibliography

1. Barbe CH, 1995: On the contaminating esterase activities of pectolytic preparations. PhD Thesis, University of Bordeaux 2.

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