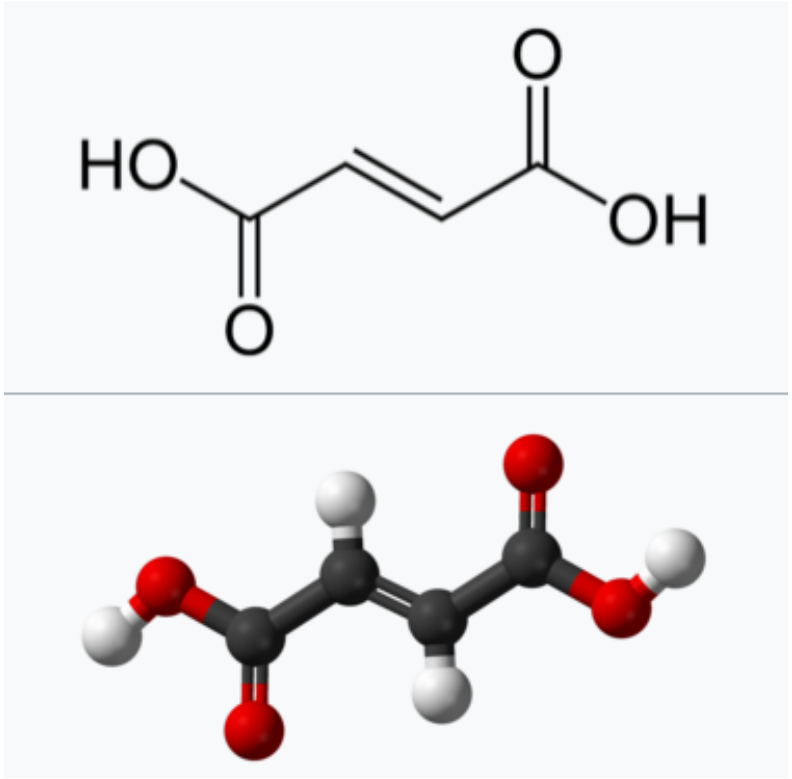
Fumaric acid



Antonio Morata
UPM
MA Bañuelos
Carmen López
Elena Adell (Campoviejo)

RESOLUTION OIV-OENO 581A-2021

TREATMENT WITH FUMARIC ACID IN WINE TO INHIBIT MALOLACTIC FERMENTATION

https://www.oiv.int/public/medias/8084/en-oiv-oeno-581a-2021.pdf

CONSIDERING that the control of MLF and the inhibition of lactic acid bacteria can help to reduce the levels of SO_2 in wines,

DECIDE following a proposal of the Commission II "Oenology" to add the fumaric acid in point of prescriptions c) of the sheet 3.4.2 "Biological Stabilisation" as an oenological practice designed to eliminate undesirable microorganisms or to inhibit their development,

DECIDE, to set up its own sheet and to introduce the treatment with fumaric acid as an additive to inhibit malolactic fermentation in wines into part II, chapter 2 of the *International Code of Oenological Practices*

Part II

Chapter 2: Wines

Sheet 3.4.X

TITLE: Treatment with fumaric acid to inhibit malolactic fermentation

Definition

Addition of fumaric acid to wine.

Certified in conformity with Paris hybrid meeting, 12th July 2021
The Director General of the OIV
Secretary of the General Assembly
Pau ROCA

OIV-OENO 581A-2021

Objectives

1) Control of the growth and activity of the lactic acid bacteria responsible of the malolactic fermentation of wine;
2) reduction of the dose of sulphur dioxide;
3) preserve malic acidity.

Prescriptions

1) Doses of 300-600 mg/L to control malolactic fermentation, even in the presence of high quantities of inoculum and during tumultuous fermentation;
2) fumaric acid must comply with the prescriptions of the *International Enological Codex*.

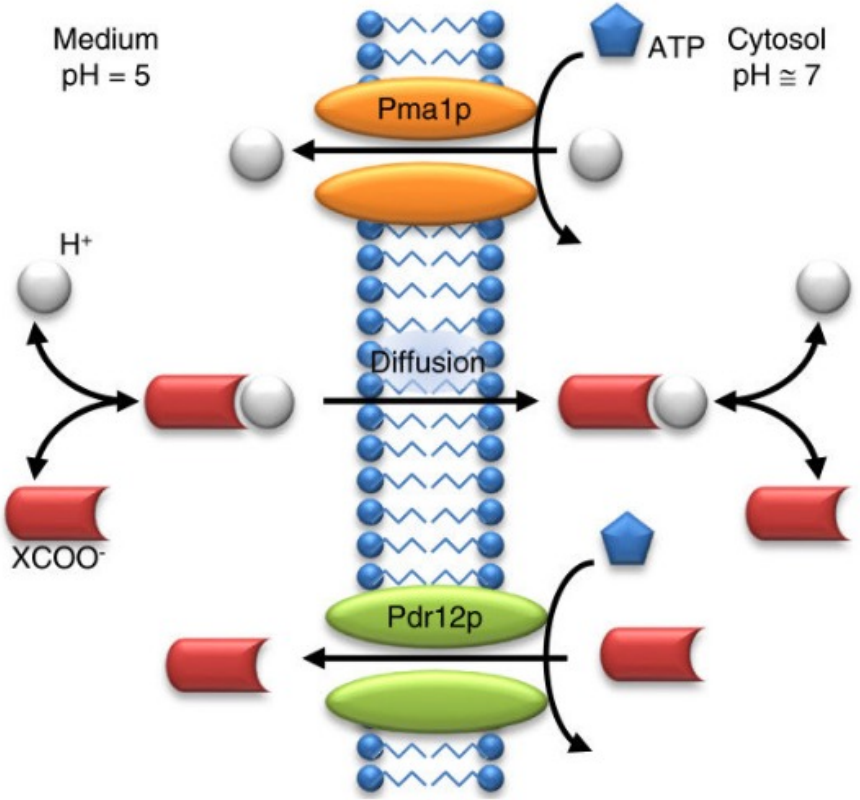
Recommendation of the OIV:

Admitted

-Organic acids such as fumarate are commonly used as antimicrobials in foods.

-Classical mechanism of **intracellular dissociation and release of protons**.

-FH2: high effectivity against: *E. coli*, *L. monocytogenes* and *Salmonella* sp.



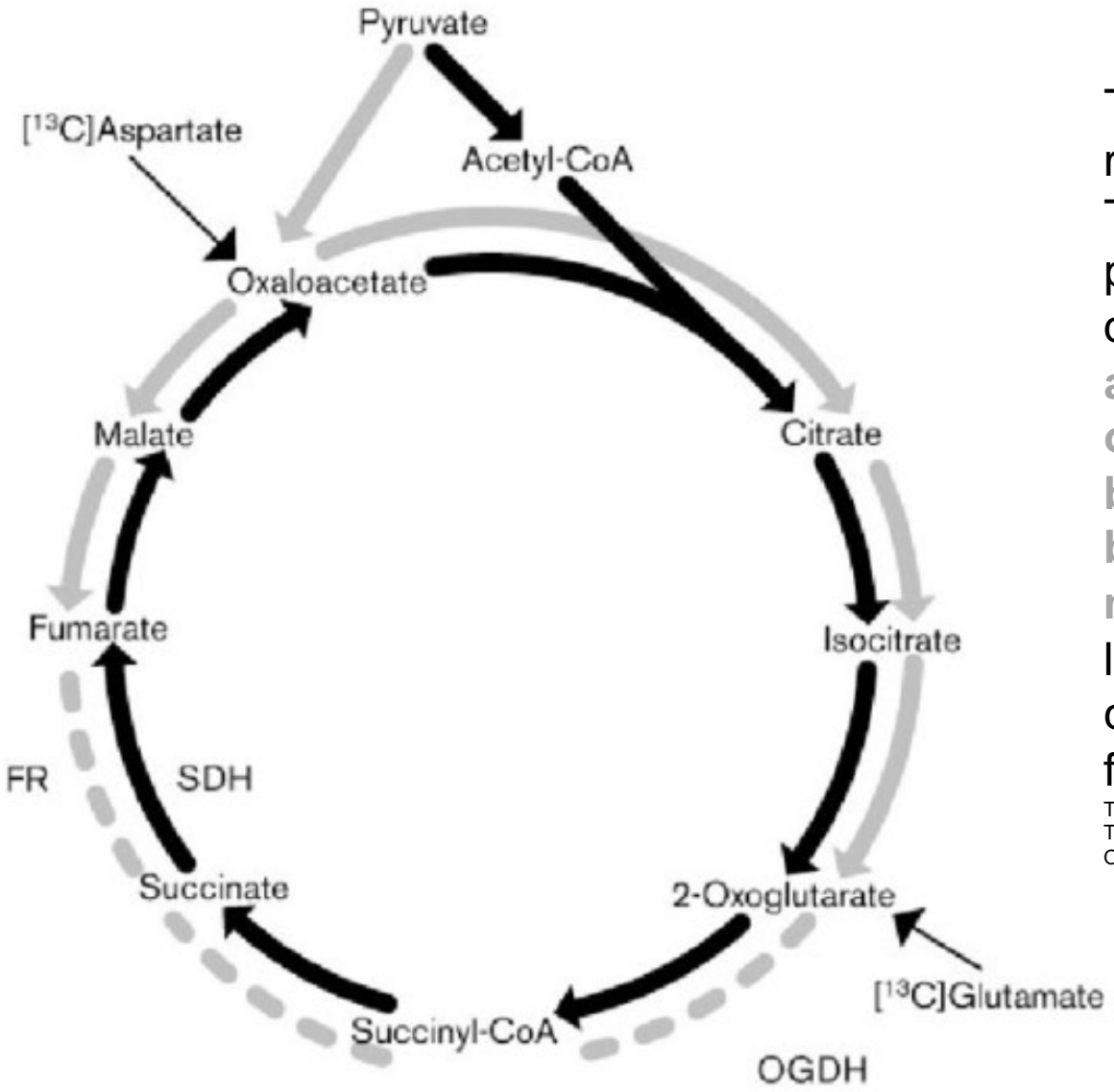
Vital-Lopez, F.G., Wallqvist, A. & Reifman, J. Bridging the gap between gene expression and metabolic phenotype via kinetic models. BMC Syst Biol 7, 63 (2013). https://doi.org/10.1186/1752-0509-7-63

Antimicrobial effect of weak organic acids (WOAs) and resistance mechanisms of S. cerevisiae . At low extracellular pH, WOAs are mainly in their undissociated form, which can diffuse through the cellular membrane. The WOAs dissociate in the cytosol and the cell responds by upregulating transporter proteins, such as Pma1 and Pdr12, to secrete protons and carboxylate anions (XCOO-), respectively, to avoid toxicity.

Additional mechanisms which are not well-defined. Fumarate, based on its **low dissociation constants** is expected to have a low antimicrobial activity which is not the case, suggesting additional antimicrobial effects:

Intracellular GAD system (GADi) or other acid resistance systems

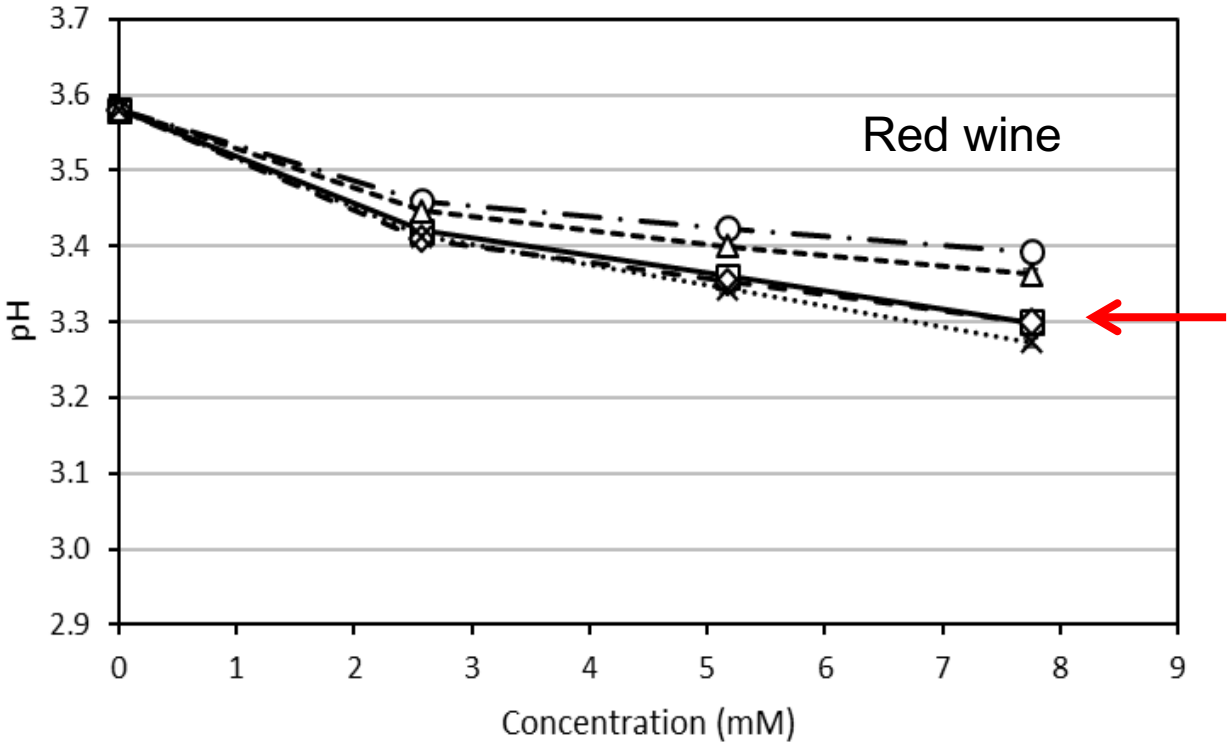
The GAD system converts glutamate to γ-amino butyric acid (GABA) with the removal of a proton resulting in an increase in the intracellular pH

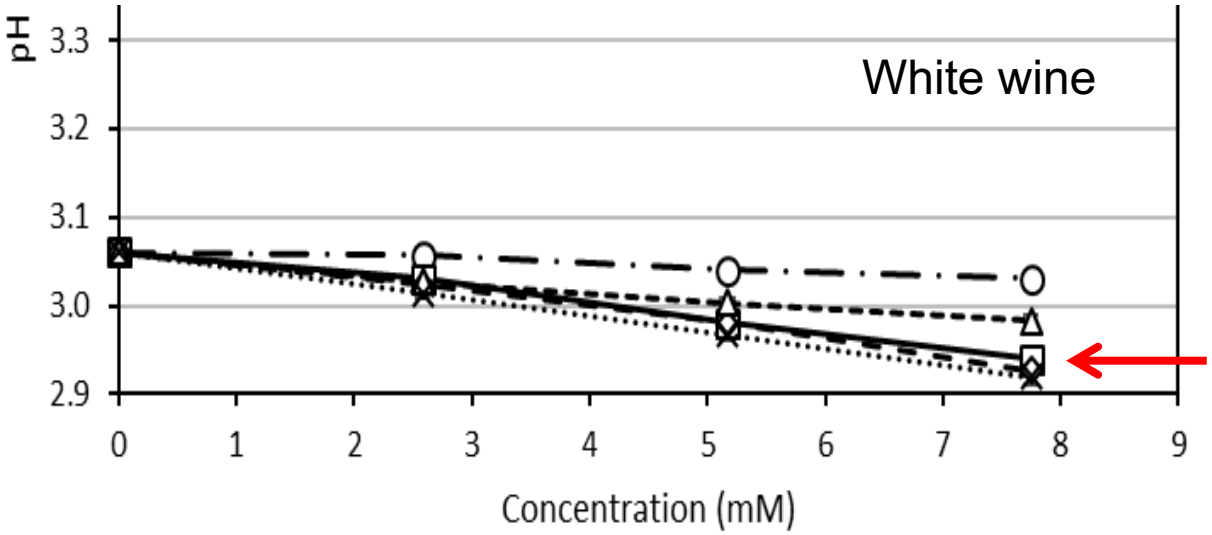


TCA pathways during respiration and fermentation. Thick black arrows, the TCA pathway functions as a cycle during respiration. **Solid grey arrows, the TCA pathway operates as an oxidative branch and a reductive branch during fermentative metabolism.** Broken grey line, the point at which the cycle is interrupted during fermentation is not identified.

Thin black arrow, aspartate and glutamate are deaminated into TCA intermediates. FR, fumarate reductase; SDH, SDH complex; OGDH, OGDH complex.

Camarasa, C., Grivet., J.-P., Dequin, S. Investigation by 13C-NMR and tricarboxylic acid (TCA) deletion mutant analysis of pathways for succinate formation in *Saccharomyces cerevisiae* during anaerobic fermentation. Microbiology 2003, 149. https://doi.org/10.1099/mic.0.26007-0





POLITÉCNICA
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INTERNATIONAL CAMPUS OF EXCELLENCE

FM2≈CH3

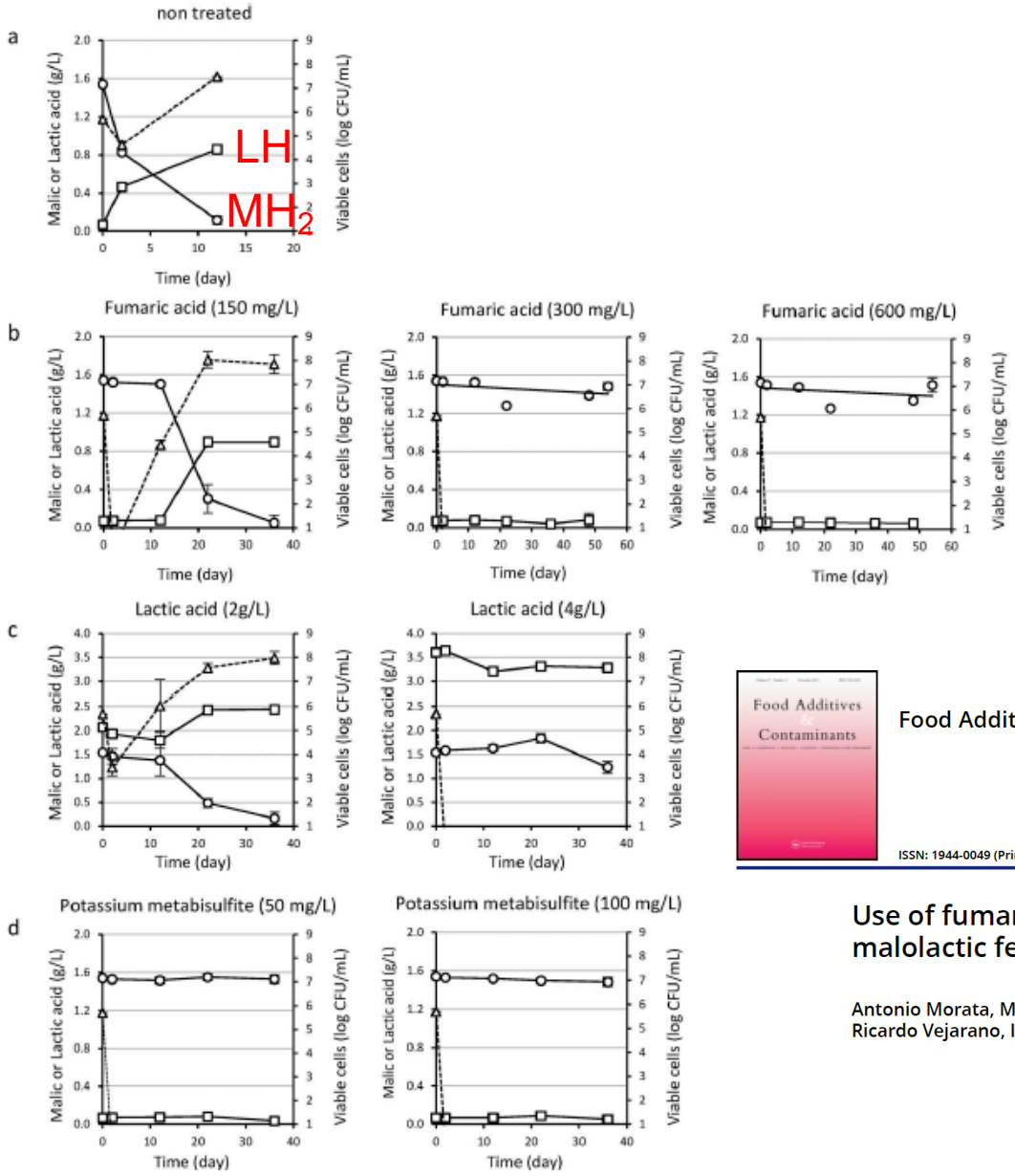

Figure 3. Malic and lactic acid concentrations (circles and squares, respectively) and viable cells of *O. oeni* (triangles and dotted line) during malolactic fermentation of wine in control (a), treated with different fumaric acid concentrations (b), lactic acid concentrations (c) or potassium metabisulfite concentrations (d). Means ± standard deviation of three replicates.

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Inhibitory FML 300-600 mg/L
Some effect 150 mg/L
Lactic acid needs 4 g/L

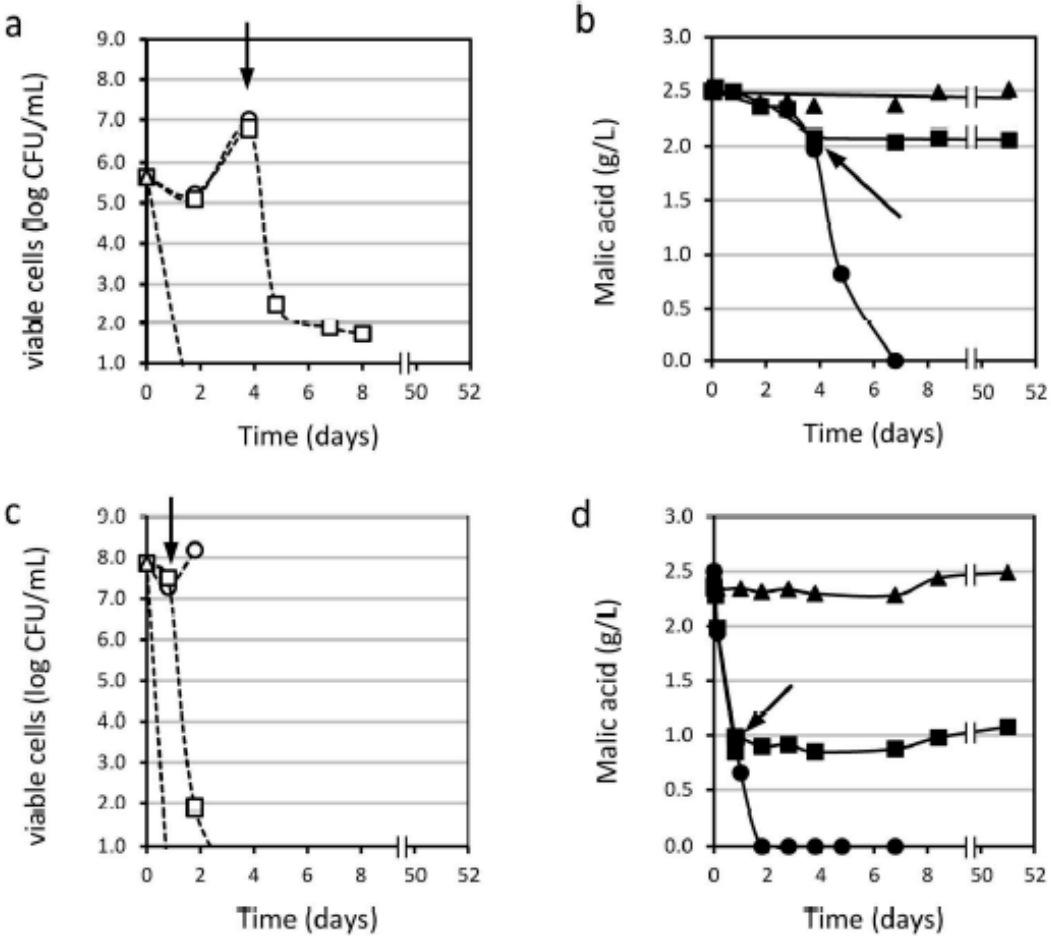
Taylor & Francis

Food Additives & Contaminants: Part A

ISSN: 1944-0049 (Print) 1944-0057 (Online) Journal homepage: https://www.tandfonline.com/loi/tfac20

Use of fumaric acid to control pH and inhibit malolactic fermentation in wines

Antonio Morata, María Antonia Bañuelos, Carmen López, Chenli Song, Ricardo Vejarano, Iris Loira, Felipe Palomero & Jose Antonio Suarez Lepe



Food Additives & Contaminants: Part A
ISSN: 1944-0049 (Print) 1944-0057 (Online) Journal homepage: https://www.tandfonline.com/loi/tfac20

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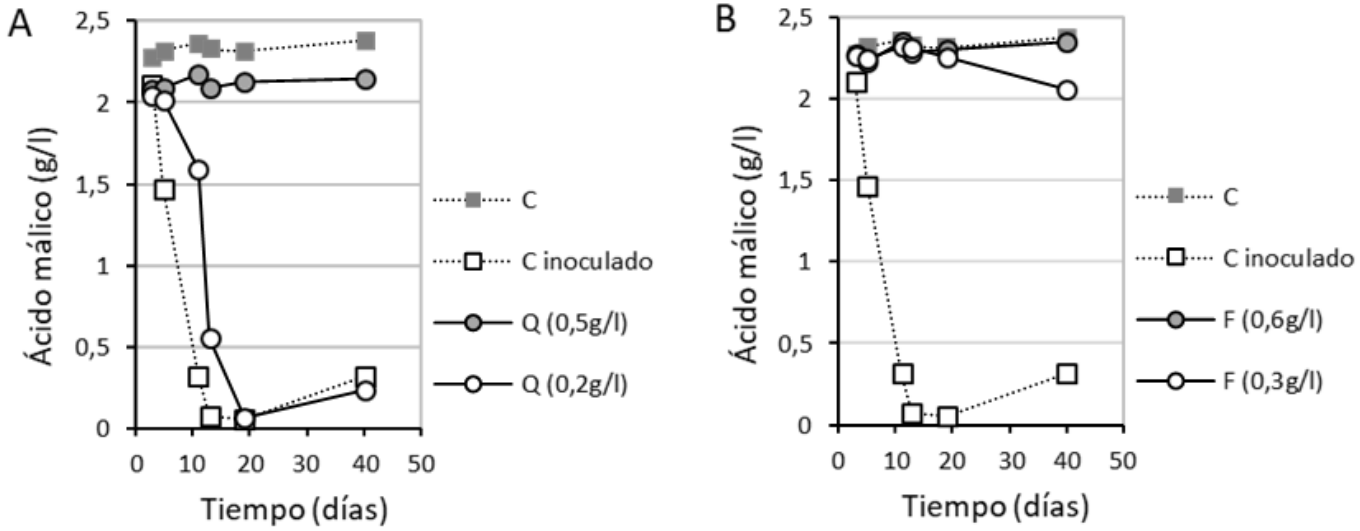
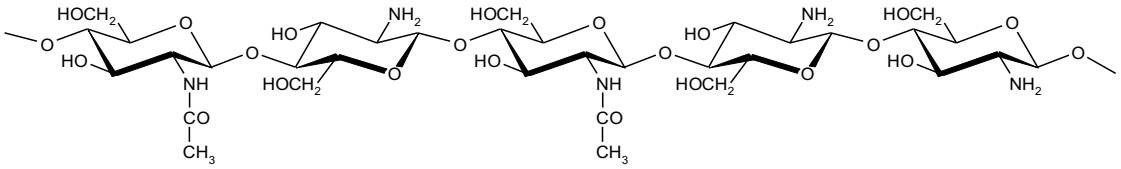
Even with 10^8 cfu/mL; FML <48h

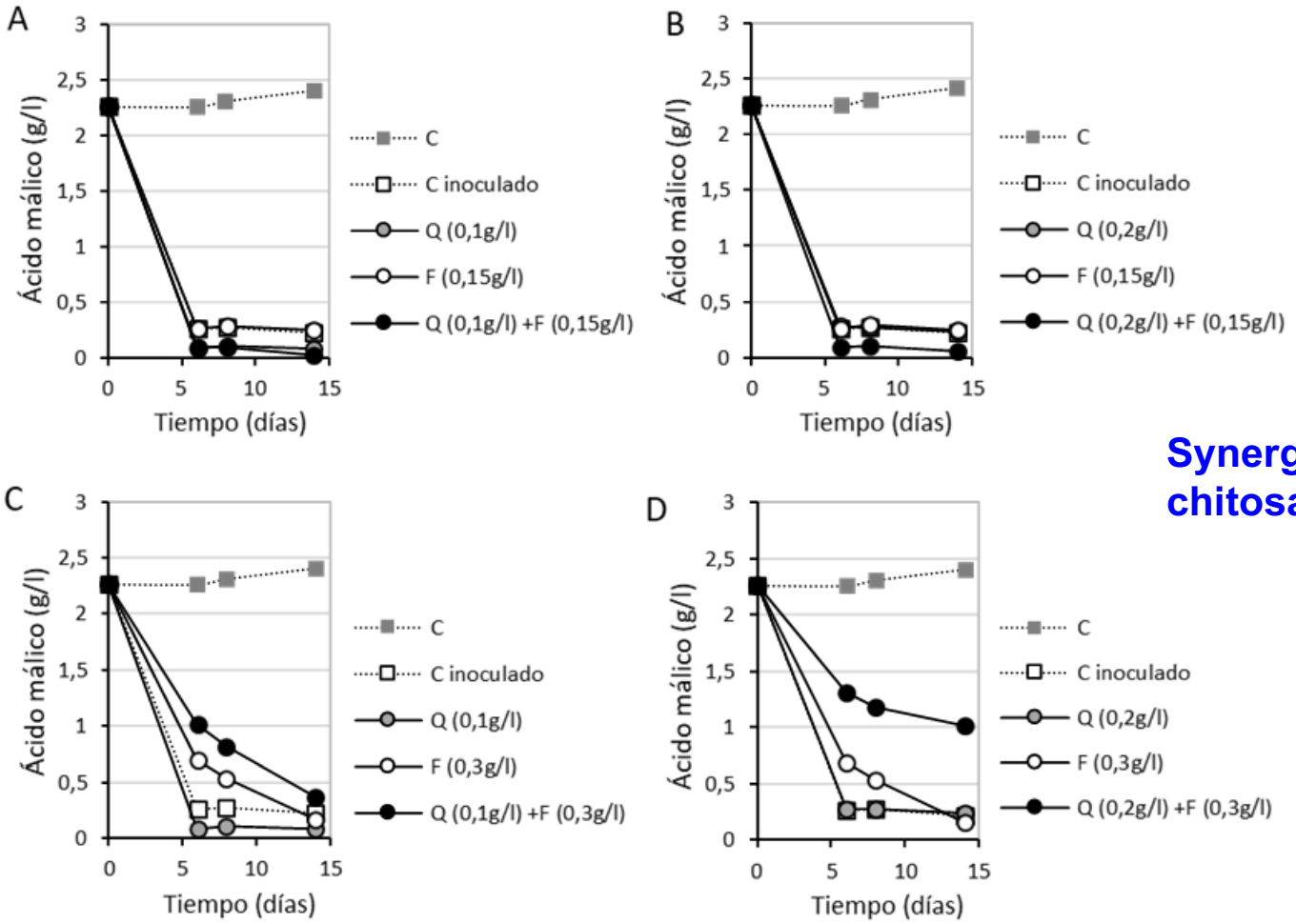
Figure 4. Viable cells of *O. oeni* (a, c) and malic acid concentration (b, d) during MLF in absence (circles) or presence of 600 mg/L fumaric acid added at time 0 (triangles) or at the day indicated by the arrows (squares). In (a, b) the wine was inoculated with 4×10^5 CFU/mL and in (c, d) with 7×10^7 CFU/mL. Values are means ± standard deviation of three replicates.



Figura·2.·Efecto·del·quitosano·(Q;·0,2·y·0,5·g/l;·a)·y·del·ácido·fumárico·(F;·0,3·y·0,6·g/l;·b)·en·la· degradación·de·ácido·málico·durante·la·FML·de·un·vino·tinto·inoculado·con·una·población· inicial·7-log·CFU/mL.¶



http://www.acenologia.com/cienciaytecnologia/fml_fumarico_quitosano_cienc176_0620.htm



Synergic effect with chitosan

¶

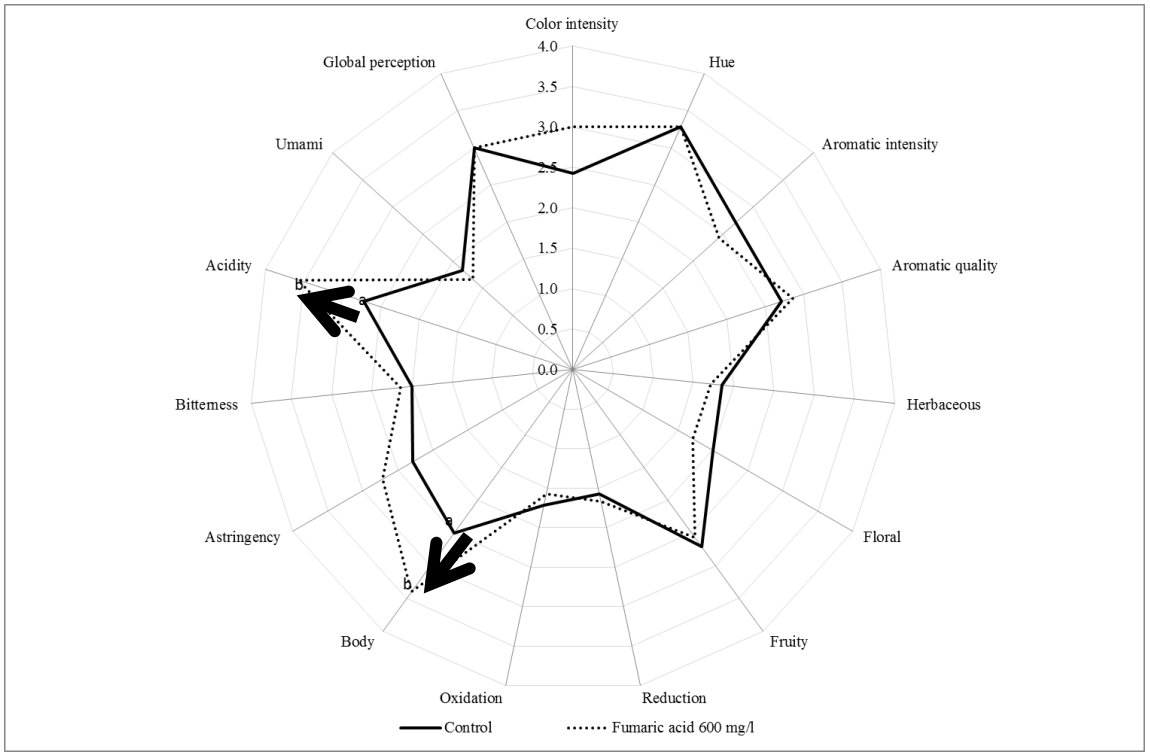
Figura·3.·Efecto·conjunto·del·quitosano·(Q;·0,1·y·0,2·g/l)·y·del·ácido·fumárico·(F;·0,15·y·0,3·g/l)·en·la·degradación·de·ácido·málico·durante·la·FML·de·un·vino·tinto·inoculado·con·una·población·inicial·8-log·CFU/mL.¶

Fumaric acid

Sensory analysis

Triangular tasting: undetected
-300 mg/L non significant
-600 mg/L non significant

No sensory effect 300-600 mg/L; triangular

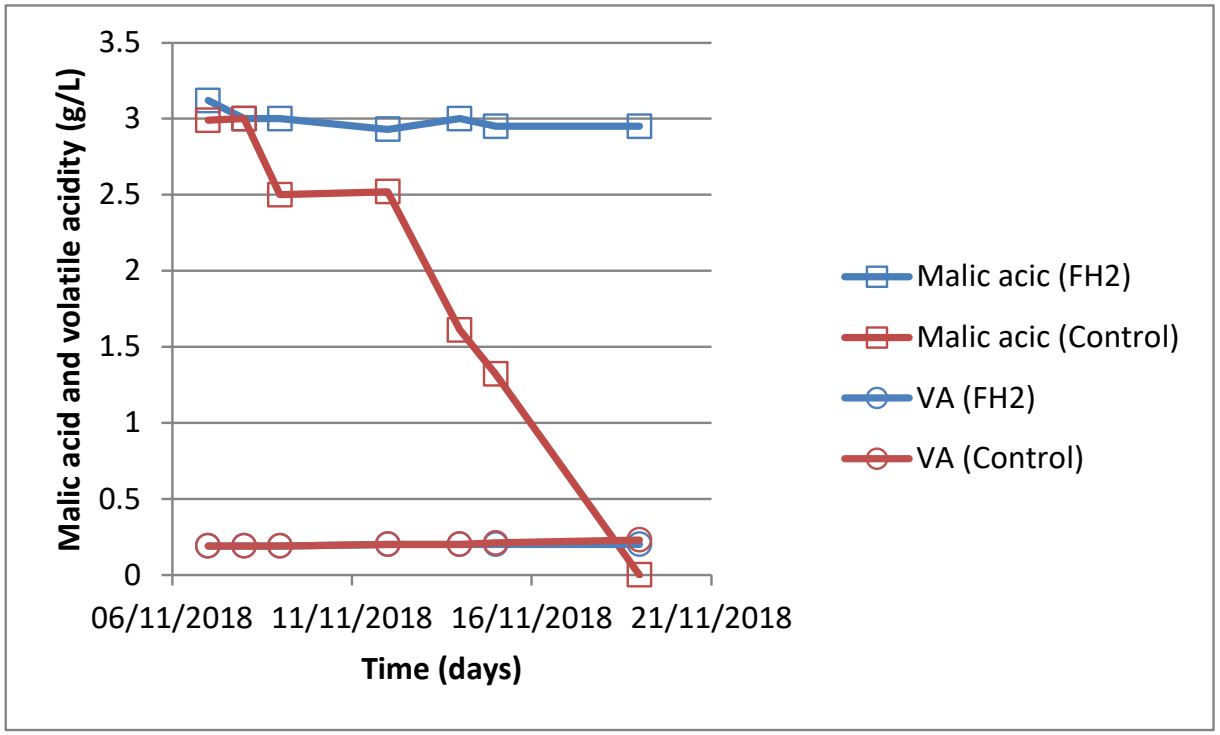


Rioja Wine. San Asensio (Rioja alta) Spontaneous FML. 22 ºC. 12+12 Bottles. Dose 600 mg/L

Fecha	Gº	AV	pH	IC	A280	AM
28/10/2018	13.04	0.17	3.49	19.18	64	3.02

Elena Adell

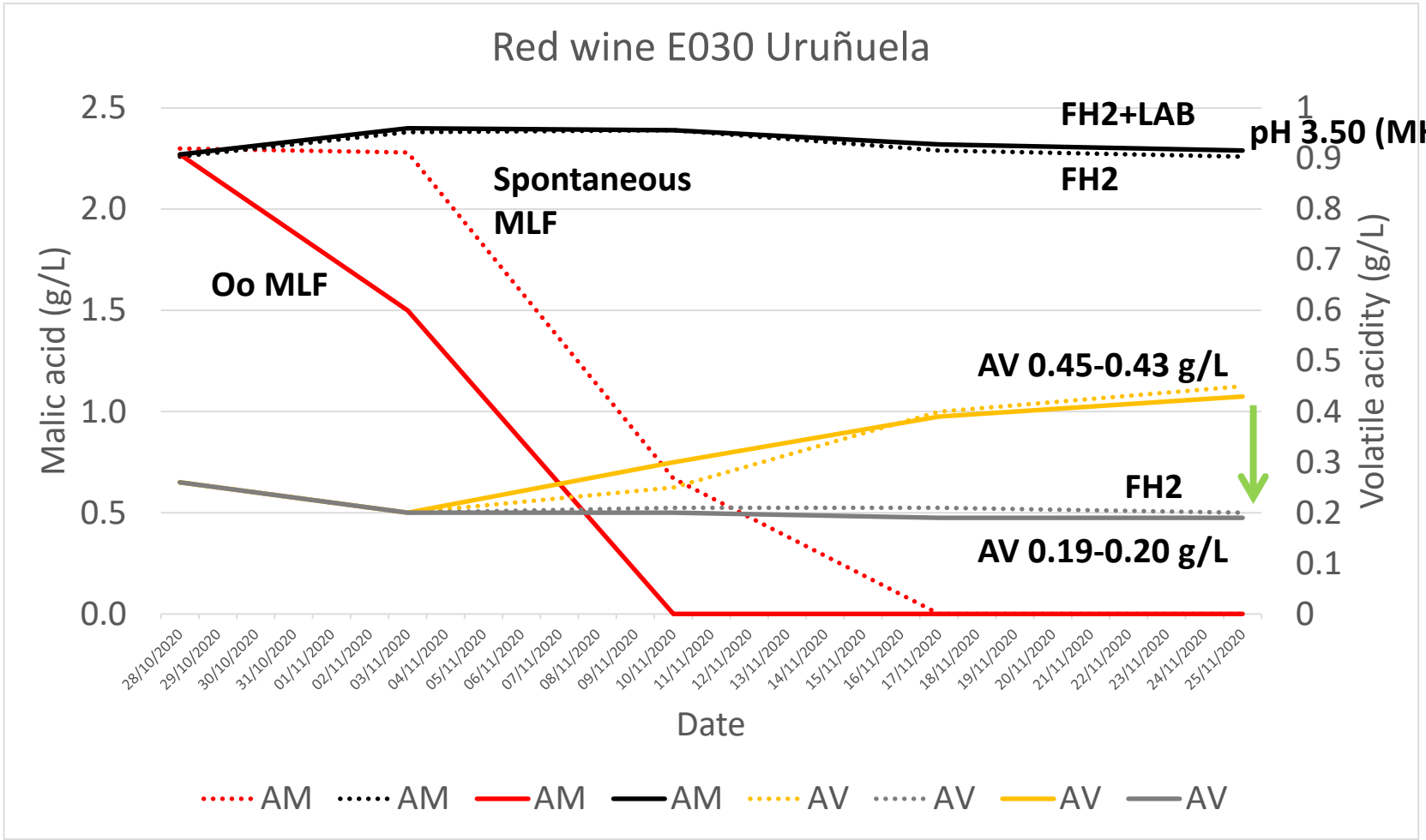
No effect in volatile acidity; 22 wines;



Red wine Uruñuela (2020)

O. Oeni cepa alpha 1g/hL

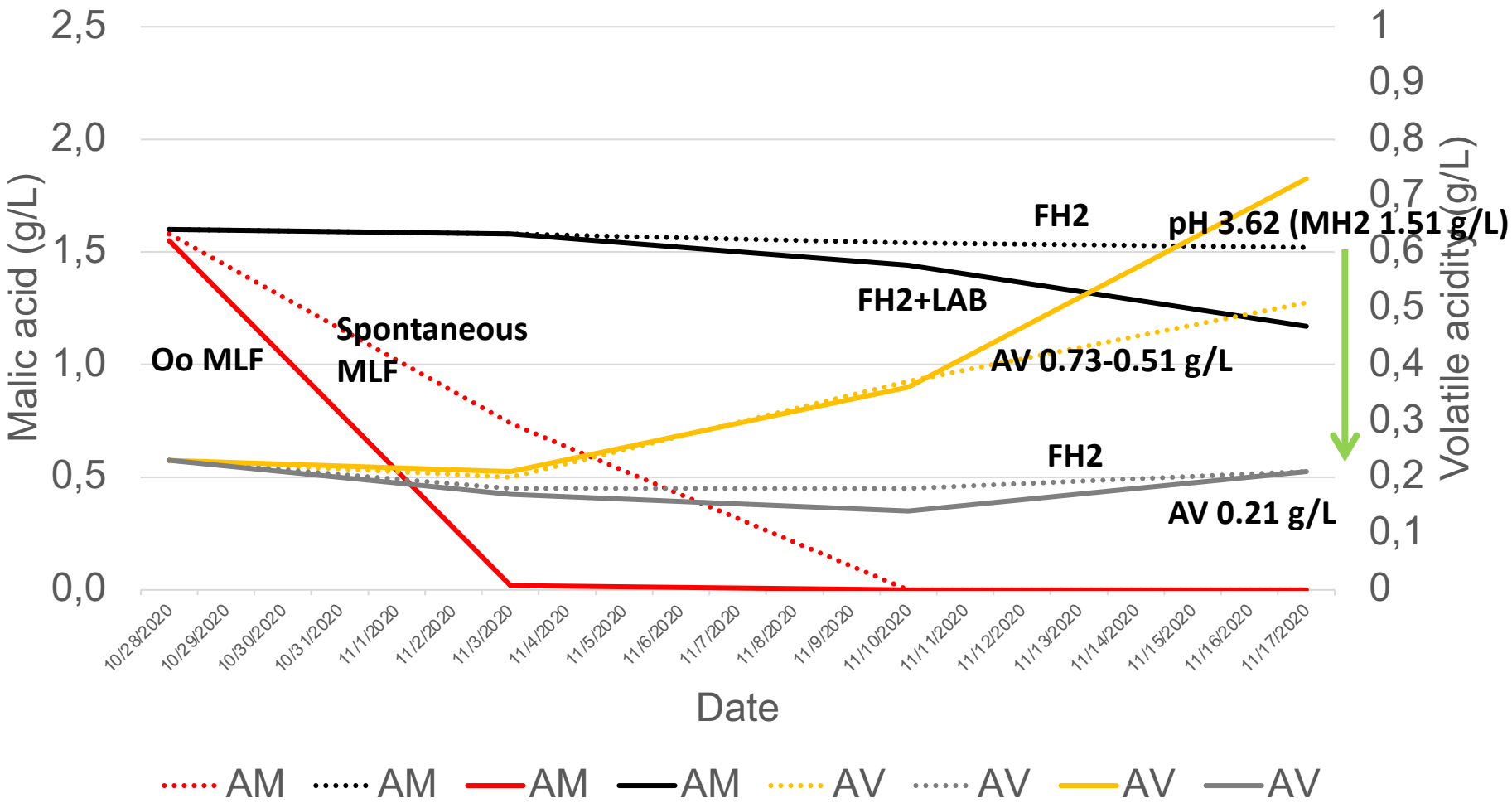
FH2 600 mg/L



Red wine Fuenmayor

O. Oeni cepa alpha 1g/hL

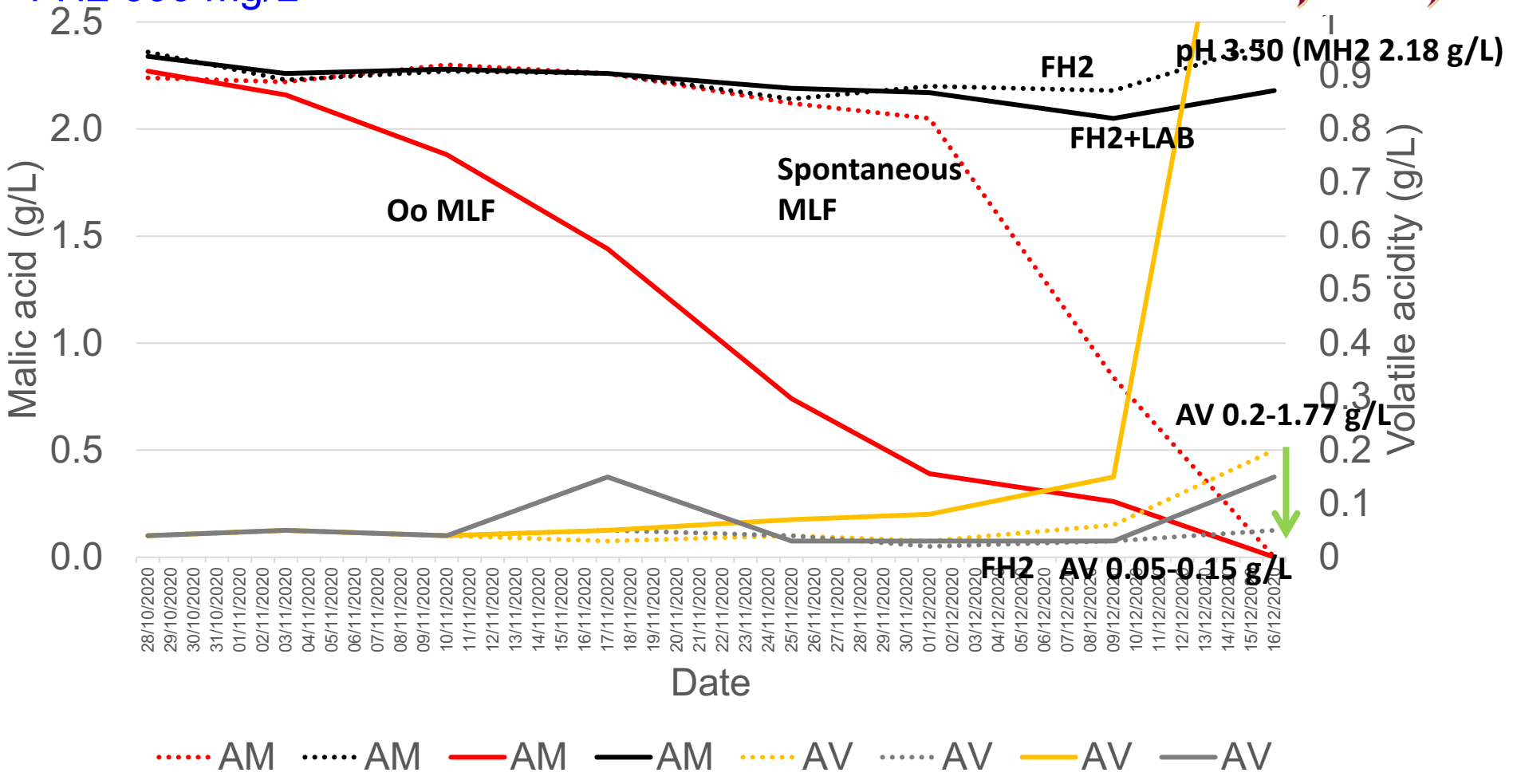
FH2 600 mg/L



Rose wine

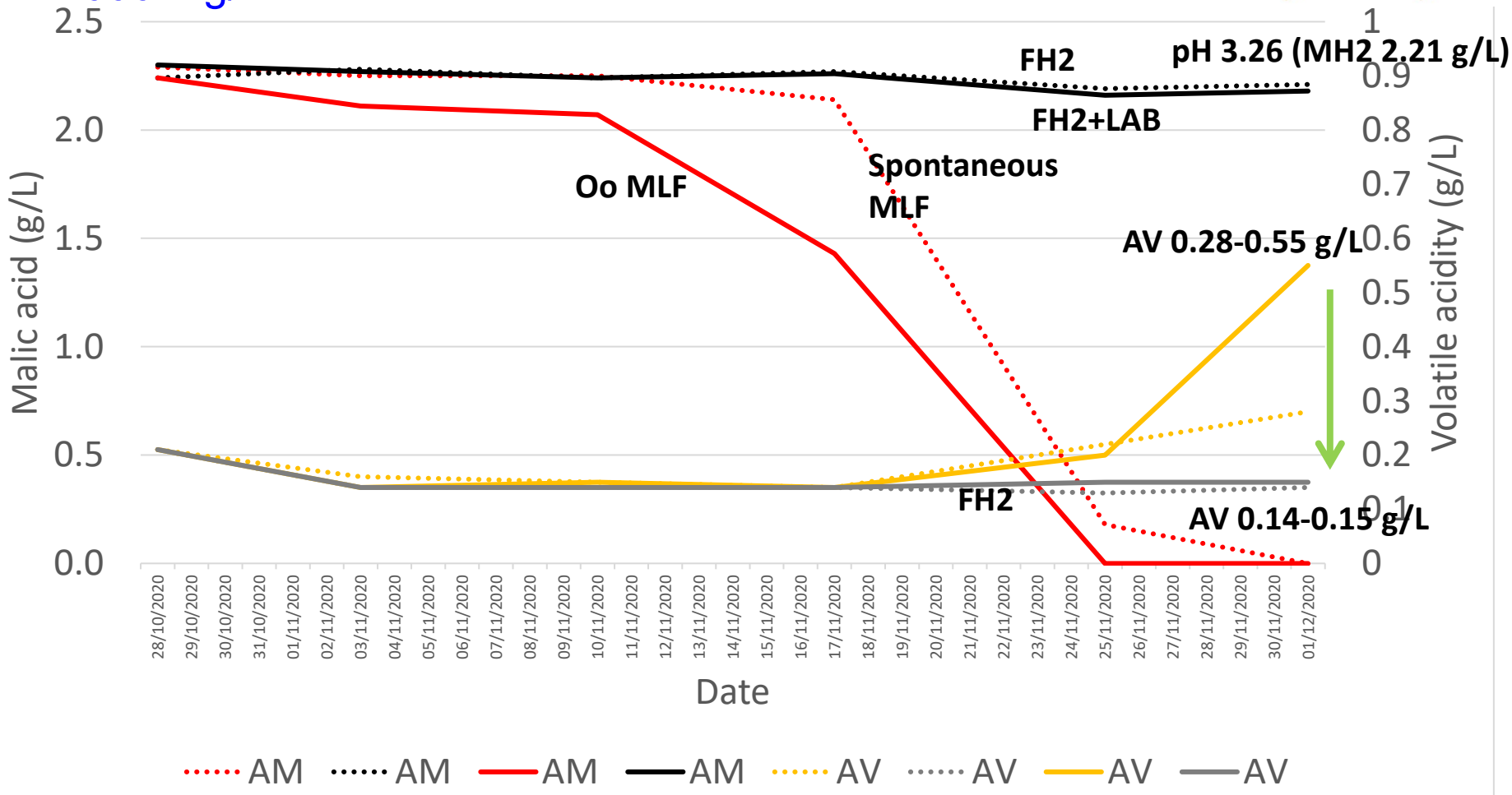
O. Oeni cepa alpha 1g/hL

FH2 600 mg/L



White wine

O. Oeni cepa alpha 1g/hL
FH2 600 mg/L

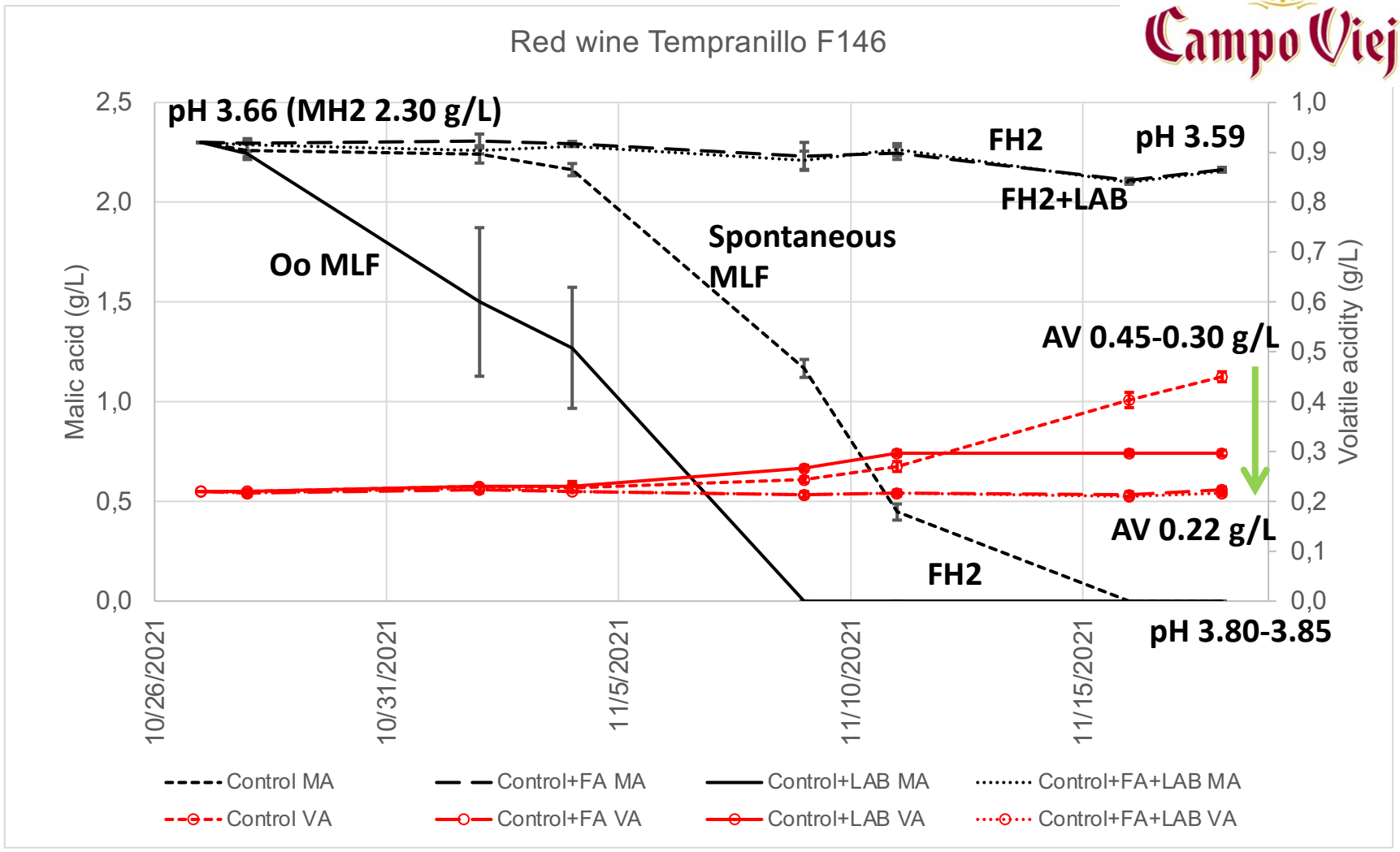


Red wine Tempranillo (2021)

O. Oeni cepa alpha 1g/hL

FH2 600 mg/L

x3 bottles

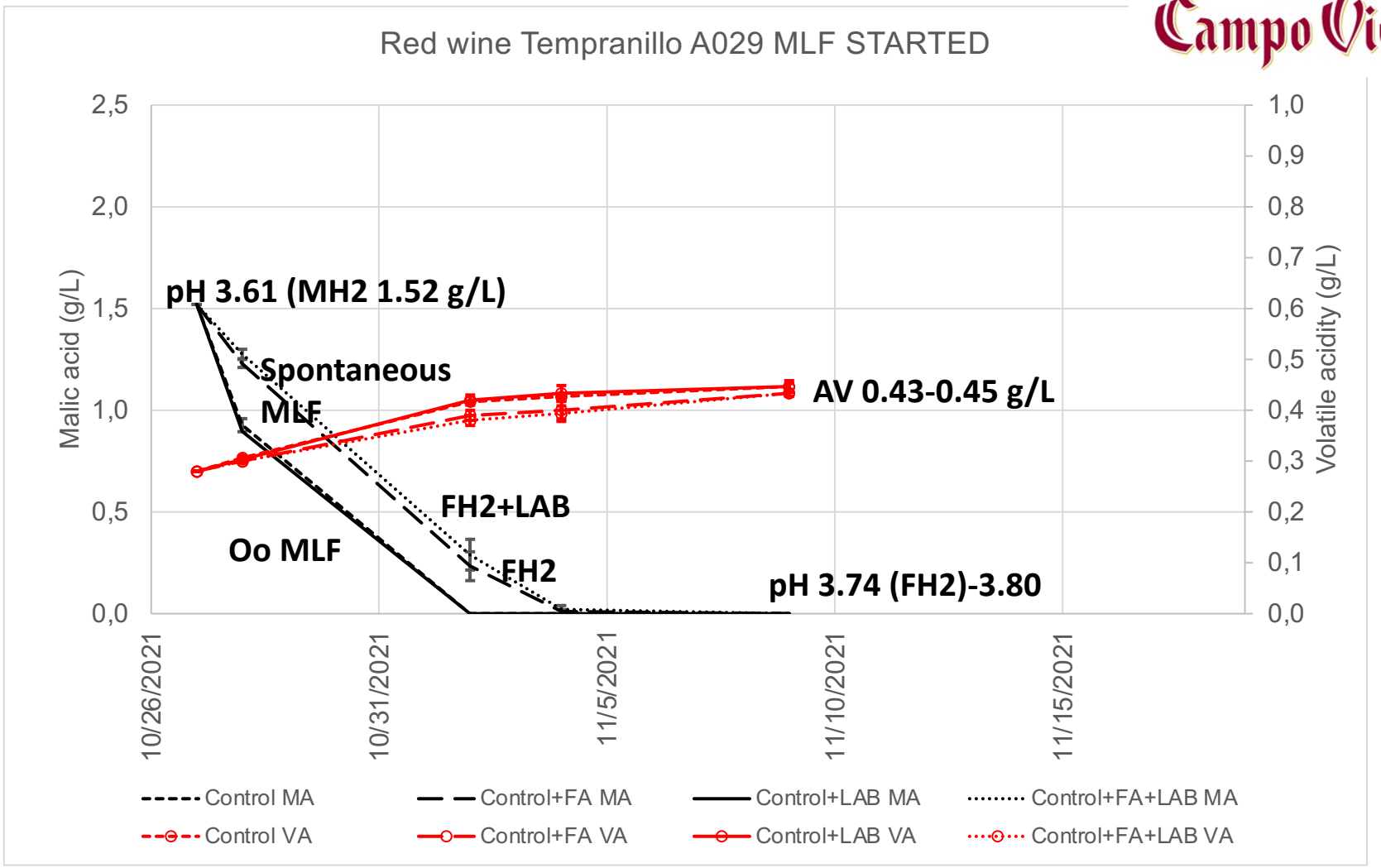


Red wine Tempranillo (2021)

MLF started. Wild LAB

FH2 600 mg/L

x3 bottles

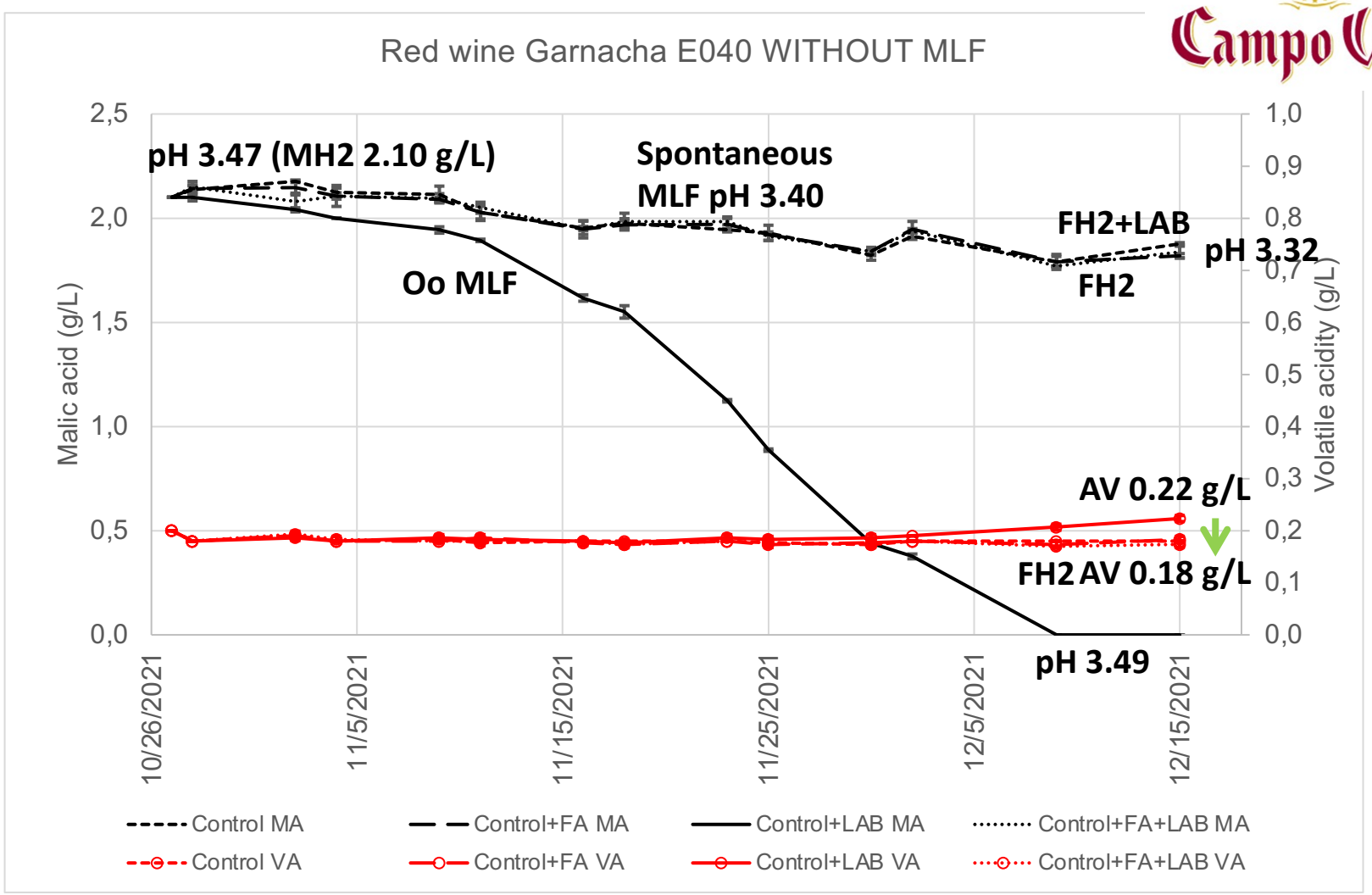


Red wine Garnacha (2021)

O. Oeni cepa alpha 1g/hL

FH2 600 mg/L

x3 bottles

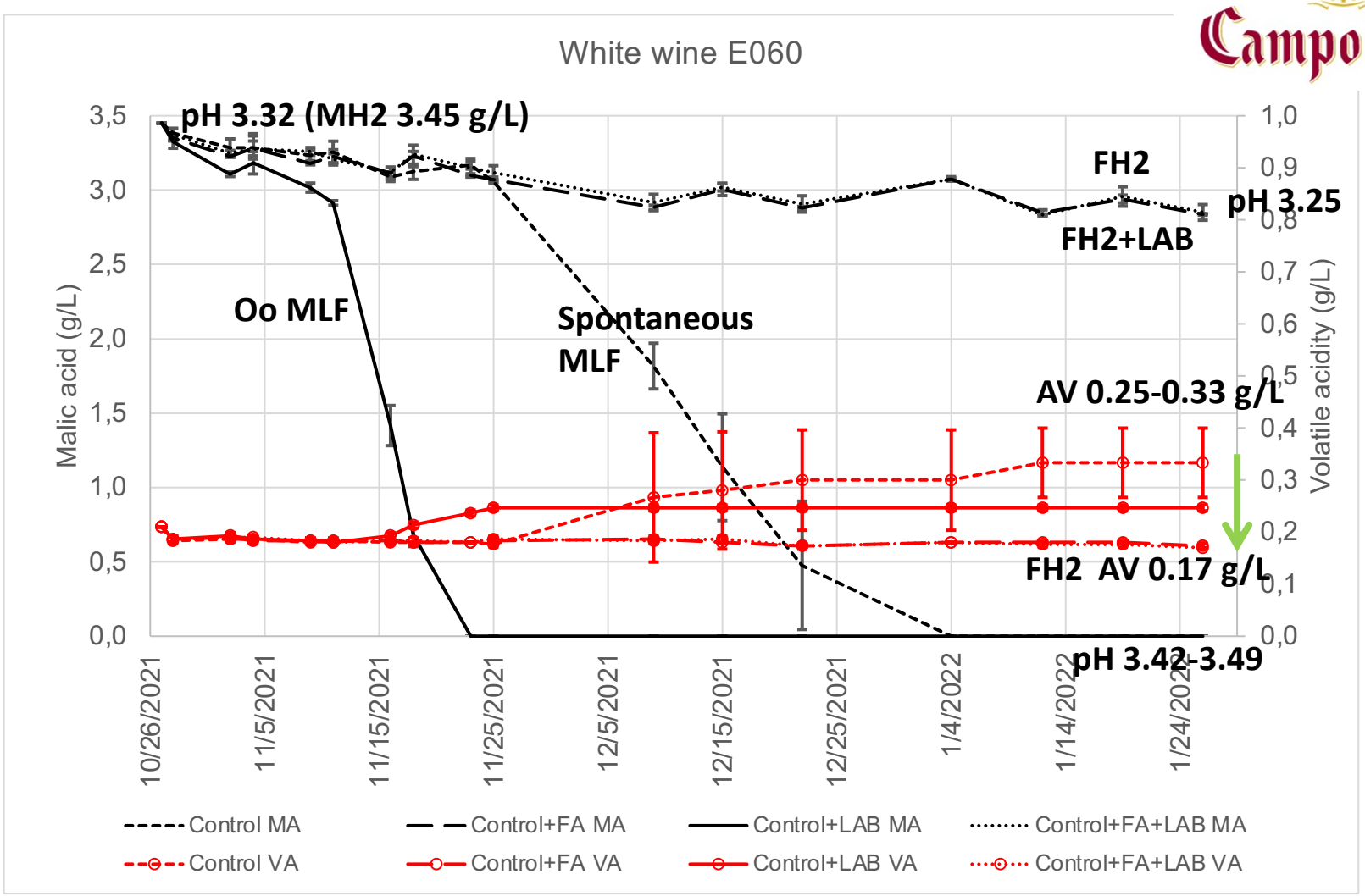


White wine Viura (2021)

O. Oeni cepa alpha 1g/hL

FH2 600 mg/L

x3 bottles

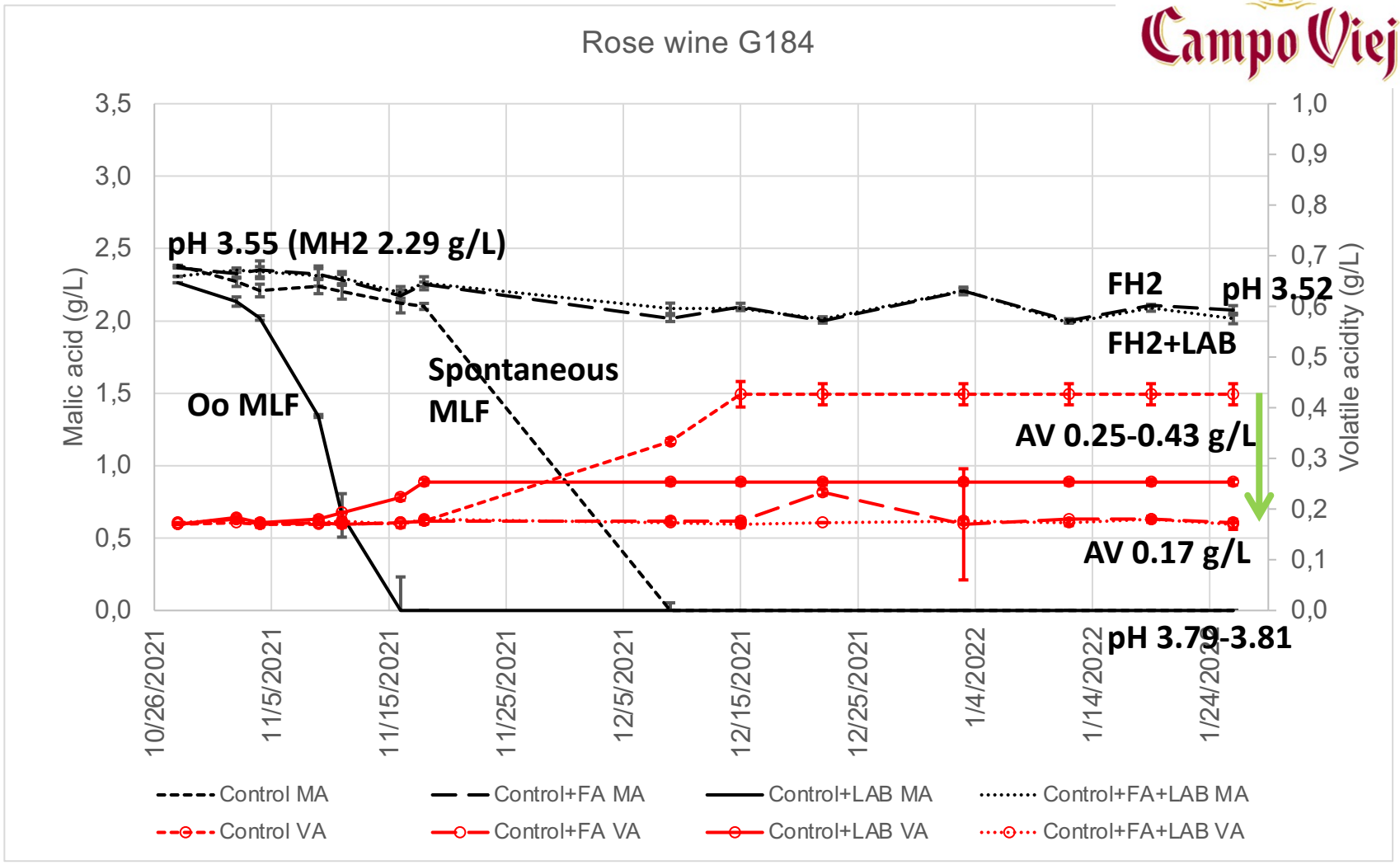


Rosé wine Tempranillo (2021)

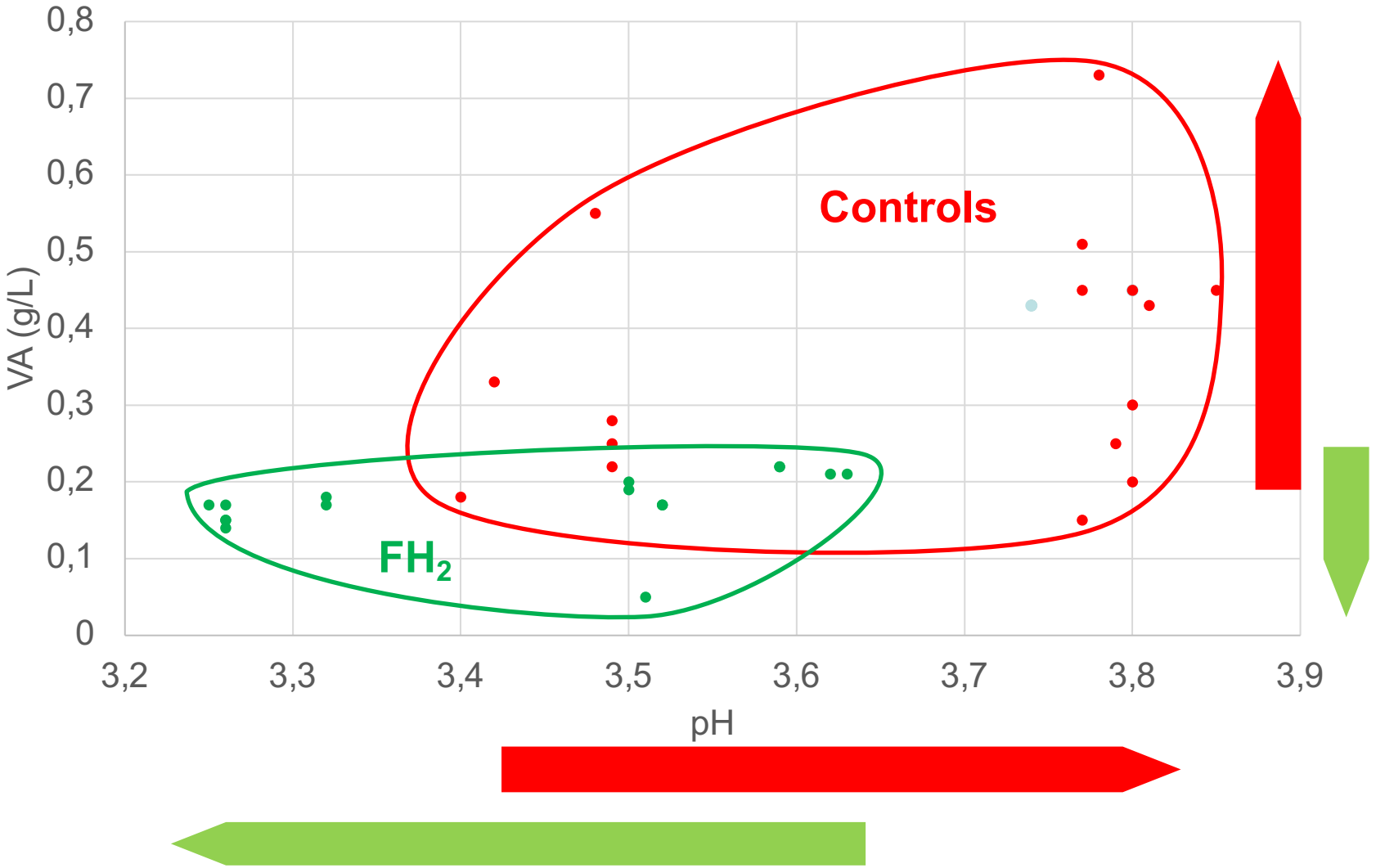
O. Oeni cepa alpha 1g/hL

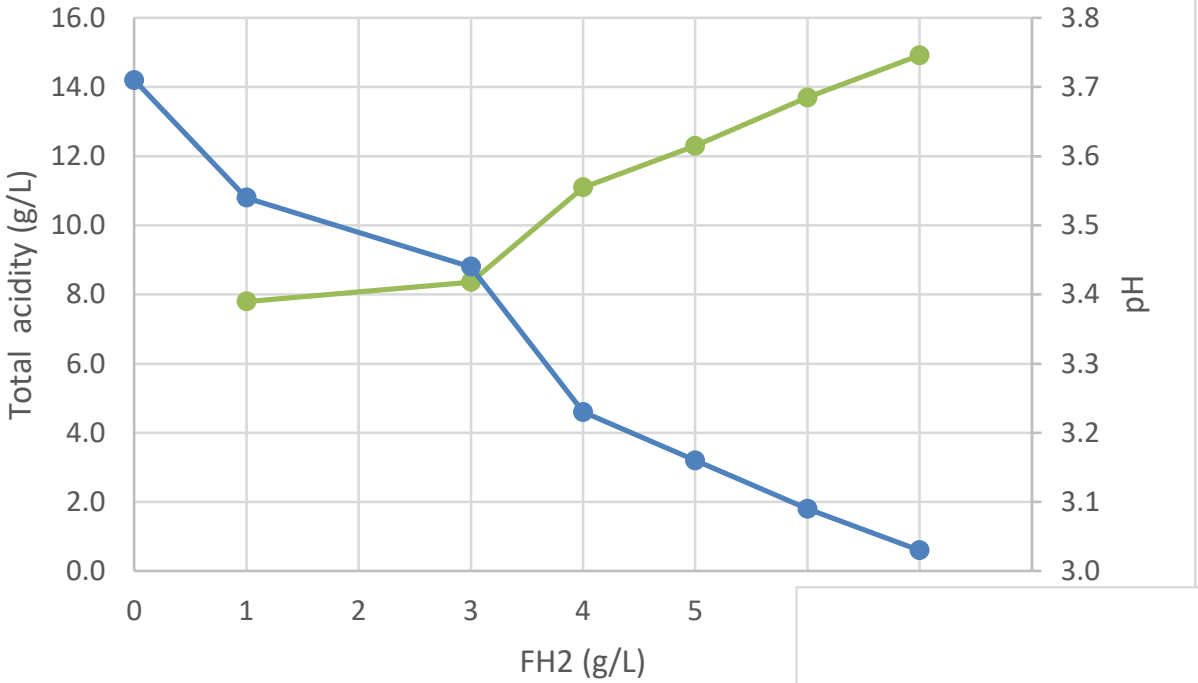
FH2 600 mg/L

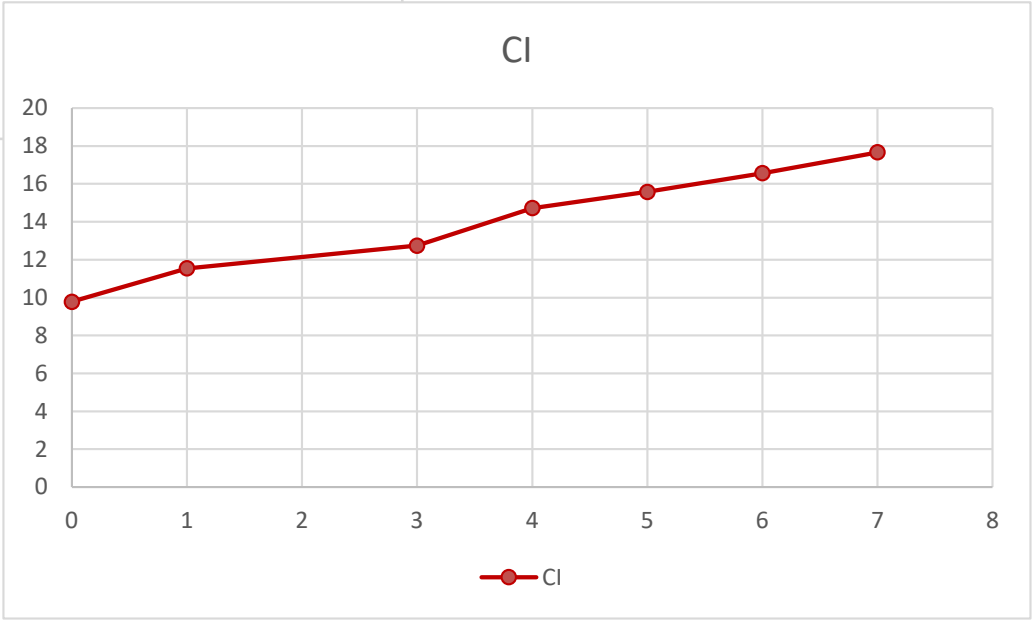
x3 bottles



pH/VA FH2 vs pH/VA without FH2 2020-2021




Total acidity (g/L)
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
0
1
2
3
4
5
FH2 (g/L)
3.8
3.7
3.6
3.5
3.4
3.3
3.2
3.1
3.0
pH


CI
20
18
16
14
12
10
8
6
4
2
0
0
1
2
3
4
5
6
7
8
CI

Sensory perception

FH2	Sensory
Control	-
1 g/L	Lower aroma intensity. Well balanced in mouth.
3 g/L	Lower aroma intensity. Fruitier in mouth.
4 g/L	Better aroma intensity. Very acidic. Unpleasant acidity
5 g/L	Revealing more fruit in nose. Extremely unpleasant acidity.
6 g/L	Balanced in aroma. Extremely unpleasant acidity.
7 g/L	Balanced in aroma. Extremely unpleasant acidity.

Conclusions

-Preservation of MH2 acidity

-Decrease of pH by FH2: 3.62 -> 3.50 (RW); 3.33 -> 3.25 (WW)

-pH preservation without MLF: 3.77 -> 3.53 (RW); 3.49 -> 3.26 (WW)

-Less volatile acidity: 0.45 -> 0.19 (RW); 0.28 -> 0.15 (WW)

-Stable red wines without MLF

-Power tool to improve freshness in warm areas

-Better physicochemical and microbiological stability

-Sparkling wines: control of undesired MLF during 2nd fermentation

Many Thanks!

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https://www.researchgate.net/profile/Antonio-Morata

https://blogs.upm.es/wineprof/

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