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DEL SUELO A LA COPA: NUEVAS ESTRATEGIAS PARA GESTIONAR EL PH EN VITICULTURA Y ENOLOGÍA

 8 de abril, 2026 (10.30 - 16.30 h)

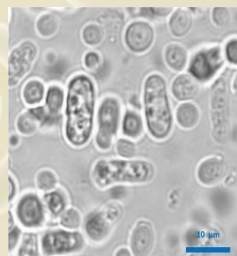
 Finca de la Grajera ICSVV (CSIC,UR,CAR)

#SomosInnovación

Nuevas tendencias en la utilización de *Lachancea thermotolerans* para la gestión biológica del pH en vinificación

Santiago Benito

Profesor Titular de Universidad
Universidad Politécnica de Madrid



<https://www.scopus.com/authid/detail.uri?origin=resultslist&authorId=24467296500&zone=>

<https://www.researchgate.net/profile/Santiago-Benito>

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Introducción (Problemática viñedo español)

Viticultura de climas cálidos (Cambio climático)

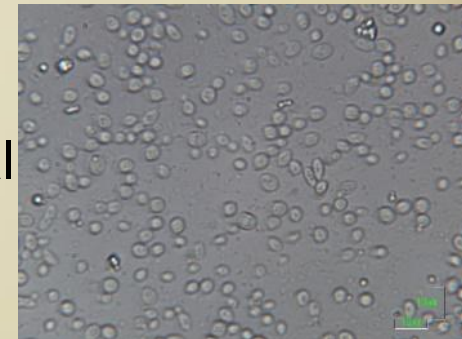


Composición uva:

- Contenido azucarado $\uparrow$ ($> 255 \text{ g/L}$) $\uparrow$
- Acidez $\downarrow$ ($\text{pH} \pm 4$ / $0.4\text{-}0.7 \text{ g/L}$ ácido málico)

Posibles problemas:

- Vinos desequilibrados desde un punto de vista sensorial
- Finales difíciles de fermentación alcohólica.
- Deterioro parámetros de calidad.



Benito S (2020) Combined use of *Lachancea thermotolerans* and *Schizosaccharomyces pombe* in winemaking: A review. Microorganisms 8: 655.

<https://www.mdpi.com/2076-2607/8/5/655>

Problemática viñedo español

Viticultura de climas cálidos (Cambio climático)



CONSEJO REGULADOR DE LA DENOMINACIÓN DE ORIGEN CALIFICADA "RIOJA"

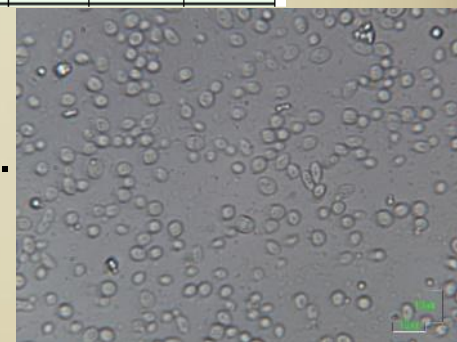
Calle Estambrera nº 52 · 26006 Logroño (La Rioja)



ÁREA	ZONA	T.M.	PARAJE	VARIEDAD	AÑO	COTA	MUESTRA Nº	Peso 100 granos	Grado Alcohólico Probable (% Vol)	Acidez Total Tárrica (g/l)	pH	Ácido Málico	Potasio (mg/l)	IPT	Antocianos	Intensidad Colorante
I				Tempranillo	1993	438	1	250,59	13,45	4,60	3,85	2,72	2450	42,44	493,25	12,06
III				Tempranillo	1987	440	6	205,31	14,15	4,15	3,99	3,00	2590	46,09	653,99	15,13
XIV				Garnacha	2000	397	40	194,74	14,56	5,80	3,37	0,38	1310	38,96	301,48	10,26
XIV				Graciano	2002	325	41	127,82	15,11	5,60	3,64	0,82	2230	54,47	829,51	27,53
XIV				Garnacha	1996	325	37	201,74	15,51	3,80	3,72	0,78	2060	44,05	329,43	7,83
XVI				Garnacha	1998	362	44	174,00	14,27	5,00	3,36	0,50	1705	38,00	302,00	9,90
XVII				Garnacha	1990	371	47	170,40	14,13	5,00	3,29	0,50	1784	32,00	174,00	7,50
XVIII				Tempranillo	2000	515	50	205,89	14,20	4,37	3,90	3,35	-	48,00	721,00	17,60

Posibles problemas:

- Vinos desequilibrados desde un punto de vista sensorial.
- Finales difíciles de fermentación alcohólica.
- Deterioro parámetros de calidad.



Benito S (2020) Combined use of *Lachancea thermotolerans* and *Schizosaccharomyces pombe* in winemaking: A review. *Microorganisms* 8: 655.

<https://www.mdpi.com/2076-2607/8/5/655>

Introducción *non-Saccharomyces*

Principal interés enológico de *Lachancea* y *Schizosaccharomyces*

Yeast species	Oenological interest	
<i>Kloeckera apiculata</i>	A	MINI-REVIEW
<i>Hanseniaspora vineae</i>	A	The impacts of <i>Lachancea thermotolerans</i> yeast strains on winemaking
<i>Torulospira delbrueckii</i>	A	Santiago Benito ¹
<i>Metschnikowia pulcherrima</i>	A	Received: 8 April 2018 / Revised: 17 May 2018 / Accepted: 18 May 2018 / Published online: 6 June 2018 © Springer-Verlag GmbH Germany, part of Springer Nature 2018
<i>Starmerella bacillaris</i>	A	Abstract At one time, <i>Saccharomyces</i> spp. yeasts were the only option for use in winemaking due to their unique abilities to metabolize all grape juice sugars to ethanol. However, during the previous decade, several commercial non- <i>Saccharomyces</i> yeast products appeared in the biotechnology market. Some of them have slowly begun to establish new enological resources to solve modern winemaking challenges in the new century. Among these challenges, acidification in the warm-growing regions is of great concern for improving wine quality from those areas, particularly in light of the predictions of serious climate change. This review explores one of the most popular commercialized non- <i>Saccharomyces</i> yeast options in warm viticultural regions, <i>Lachancea thermotolerans</i> , and its influences on wine quality parameters, such as lactic acid, ethanol, glycerol, volatile acidity, volatile profiles, isovaleric acid, mannoproteins, polysaccharides, color, anthocyanins, amino acids, and sensory perception.
<i>Zygosaccharomyces bailii</i>	Pc	
<i>Pichia guilliermondii</i>	Fc	Keywords <i>Lachancea thermotolerans</i> · Non- <i>Saccharomyces</i> · Volatile compounds · Lactic acid · Wine · Anthocyanin
<i>Pichia kluyveri</i>		Aroma complexity, increase in varietal thiols and esters.
<i>Lachancea thermotolerans</i>		Acidification, L-lactic acid production
<i>Hansenula anomala</i>		Decreased of C6 alcohols
<i>Schizosaccharomyces pombe</i>		Deacidification, L-Malic acid consumption
<i>Candida stellata</i>		High glycerol production

Benito, A., Calderón, F., & Benito, S. (2016). New Trends in *Schizosaccharomyces* Use for Winemaking. Grape and Wine Biotechnology, 1st ed. Ed, 307-323.

<https://www.intechopen.com/chapters/51980>

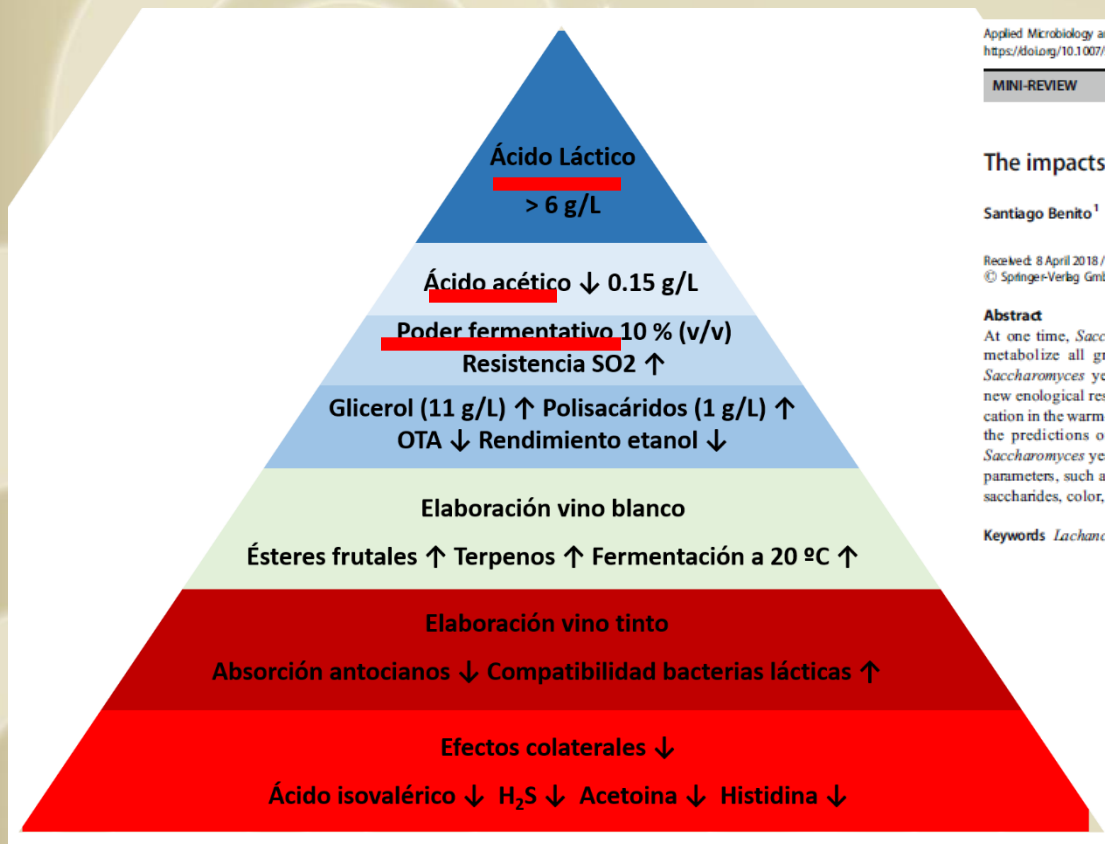
Benito, Á., Calderón, F., & Benito, S. (2019). The Influence of Non-*Saccharomyces* Species on Wine Fermentation Quality Parameters. Fermentation, 5(3), 54.

<https://www.mdpi.com/2311-5637/5/3/54>

Problemática viñedo español

Posibles Soluciones a la falta de acidez

Primeros criterios de selección *Lachancea thermotolerans*



Adaptado de:

Benito S (2018) The impacts of *Lachancea thermotolerans* yeast strains on winemaking. Appl Microbiol Biotechnol 102: 6775–6790.

<https://link.springer.com/article/10.1007/s00253-018-9117-z>

Applied Microbiology and Biotechnology (2018) 102:6775–6790
<https://doi.org/10.1007/s00253-018-9117-z>

MINI-REVIEW



The impacts of *Lachancea thermotolerans* yeast strains on winemaking

Santiago Benito¹

Received: 8 April 2018 / Revised: 17 May 2018 / Accepted: 18 May 2018 / Published online: 6 June 2018
© Springer-Verlag GmbH Germany, part of Springer Nature 2018

Abstract

At one time, *Saccharomyces* spp. yeasts were the only option for use in winemaking due to their unique abilities to metabolize all grape juice sugars to ethanol. However, during the previous decade, several commercial non-*Saccharomyces* yeast products appeared in the biotechnology market. Some of them have slowly begun to establish new enological resources to solve modern winemaking challenges in the new century. Among these challenges, acidification in the warm-growing regions is of great concern for improving wine quality from those areas, particularly in light of the predictions of serious climate change. This review explores one of the most popular commercialized non-*Saccharomyces* yeast options in warm viticultural regions, *Lachancea thermotolerans*, and its influences on wine quality parameters, such as lactic acid, ethanol, glycerol, volatile acidity, volatile profiles, isovaleric acid, mannoproteins, polysaccharides, color, anthocyanins, amino acids, and sensory perception.

Keywords *Lachancea thermotolerans* · Non-*Saccharomyces* · Volatile compounds · Lactic acid · Wine · Anthocyanin

Posibles Soluciones a la falta de acidez en mosto/vino

Solución Microbiológica => Empleo de *Lachancea thermotolerans*

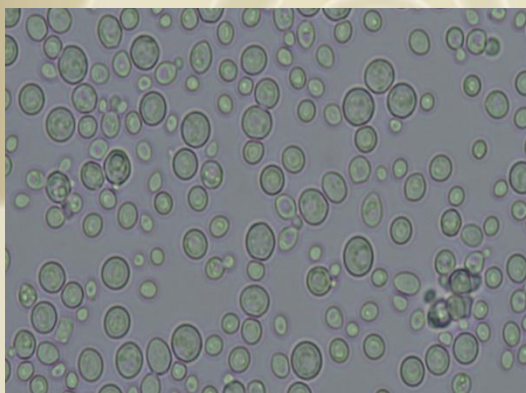


Table 3. Summary of sequential combinations between *L. thermotolerans* and *Saccharomyces* and their influence on the final lactic acid concentration, pH, and total acidity of the wine. The table reports the increases in lactic acid and total acidity and the reductions in pH that took place during alcoholic fermentation compared to the initial value of the grape juice before alcoholic fermentation.

Study	Lactic Acid (g/L) Increase	Total Acidity (g/L) Increase	pH Decrease
Kapsopoulou et al., 2007 [58]	1.8–5.13	2.04–5.2	0.13–0.3
Comitini et al., 2011 [59]	n.d.a.	1.8	0.23
Gobbi et al., 2013 [60]	6.38	5.1	0.26
Benito et al., 2015 [61]	1.22	n.d.a.	0.12
Benito et al., 2015 [62]	2.75	n.d.a.	0.22
Benito et al., 2016 [63]	3.18	n.d.a.	0.18
Balikci et al., 2016 [64]	n.d.a.	1.76–2	0.12
Benito et al., 2016 [65]	2.96	n.d.a.	0.21
Benito et al., 2017 [66]	2.44	n.d.a.	0.15
Chen et al., 2018 [67]	1.7	1.2	0.11
Dutraive et al., 2019 [54]	1.51	n.d.a.	0.2
Benito et al., 2019 [51]	1.63	n.d.a.	0.17
Morata et al., 2019 [68]	6.6	3.5	0.27
Blanco et al., 2020 [46]	7.1	5.7	0.3
Romani et al., 2020 [48]	0.78	1.58	0.26
Sgouros et al., 2020 [37]	10.4	12.08	0.29
Hranilovic et al., 2021 [14]	1–8.1	0.1–6.1	0.02–0.54
Snyder et al., 2021 [15]	0.2–6.1	0–6.2	0–0.33

n.d.a., no data available.

Fermentación
combinada

L. thermotolerans y
S. cerevisiae.

A. Láctico 1–6 g/L ↑

A. Total 1–5g/L ↑

A. pH 0.1–0.4 ↓

Vicente J; Navascués E; Calderón F; Santos A; Marquina D; Benito S (2021) An Integrative View of the Role of *Lachancea thermotolerans* in Wine Technology. Foods.

<https://www.mdpi.com/2304-8158/10/11/2878/htm>

Posibles Soluciones a la falta de acidez en mosto/vino

Solución Microbiológica => Empleo de *Lachancea thermotolerans*

Table 5. Summary of the budding time, ripening time, productivity, and enological potential of grape varieties where *Lachancea thermotolerans* has been applied.

Study	Grape Variety	Budding Time	Ripening Time	Productivity	Enological Potential
Ciani et al., 2006; Binati et al., 2021 [23,68]	Pinot Grigio	Medium-early	Early	Medium-high	Vinified in white provides a perfumed dry, alcoholic wine of medium acidity; when macerated, the body increases
Gobbi et al., 2013 [58]	Sangiovese	n.d.a.	n.d.a.	n.d.a.	n.d.a.
Benito et al., 2015; Dutraive et al., 2019 [53,59]	<u>Riesling</u>	Medium	Medium	Medium-low	Provides aromatic white wines with greenish reflections
Benito et al., 2015, 2016, 2017, 2018, 2019; Morata et al., 2019 [2,17,18,60,63,65]	<u>Tempranillo</u>	Medium-early	Medium-early	Medium	Fruity wines of intense and stable color, high alcoholic graduation, and medium-low acidity depending on the degree of ripening
Beckner Whitener et al., 2015, 2017 [72,73]	Syrah	Medium-late	Medium	Medium	Produces aromatic ruby red and purple wines, good structure,
Benito et al., 2016; Vaquero et al., 2020 [16,61]	<u>Airen</u>	Late	Late	High	Generalmente empleo aplicado en variedades de uva de maduración media a temprana.
Balikci et al., 2016 [62]	Emir	n.d.a.	n.d.a.	n.d.a.	
Beckner Whitener et al., 2016; Snyder 2021 [15,74]	Sauvignon Blanc	Medium-early	Medium	Medium-low	
Shekhawat et al., 2018 [22]	Chardonnay	Early	Early	Medium-high	terpenic aroma
Porter et al., 2019 [70]	Muscat of Alexandria	Medium-late	Medium-late	Medium	
Castrillo et al., 2019 [71]	<u>Treixadura</u>	Medium-late	Medium	High	Produces wines of good quality and moderate alcohol and acidity content in Atlantic regions
Blanco et al., 2020 [47]	<u>Mencia</u>	Medium-late	Early	Medium-high	Purple wines with elegant aromas and a good balance of alcohol and acidity
Hranilovic et al., 2021 [14]	Merlot	Medium	Medium	Medium-high	Provides fine fruity wines with an intense ruby red color, alcoholic, and with a tendency of low acidity
Escribano-Viana et al., 2021 [51]	<u>Viura</u>	Late	Late	High	Neutral and alcoholic wine of medium-low quality due to its high productivity
Korenika et al., 2021 [44]	Trnjak, Babic, Blatina, and Frankovka	n.d.a.	n.d.a.	n.d.a.	n.d.a.

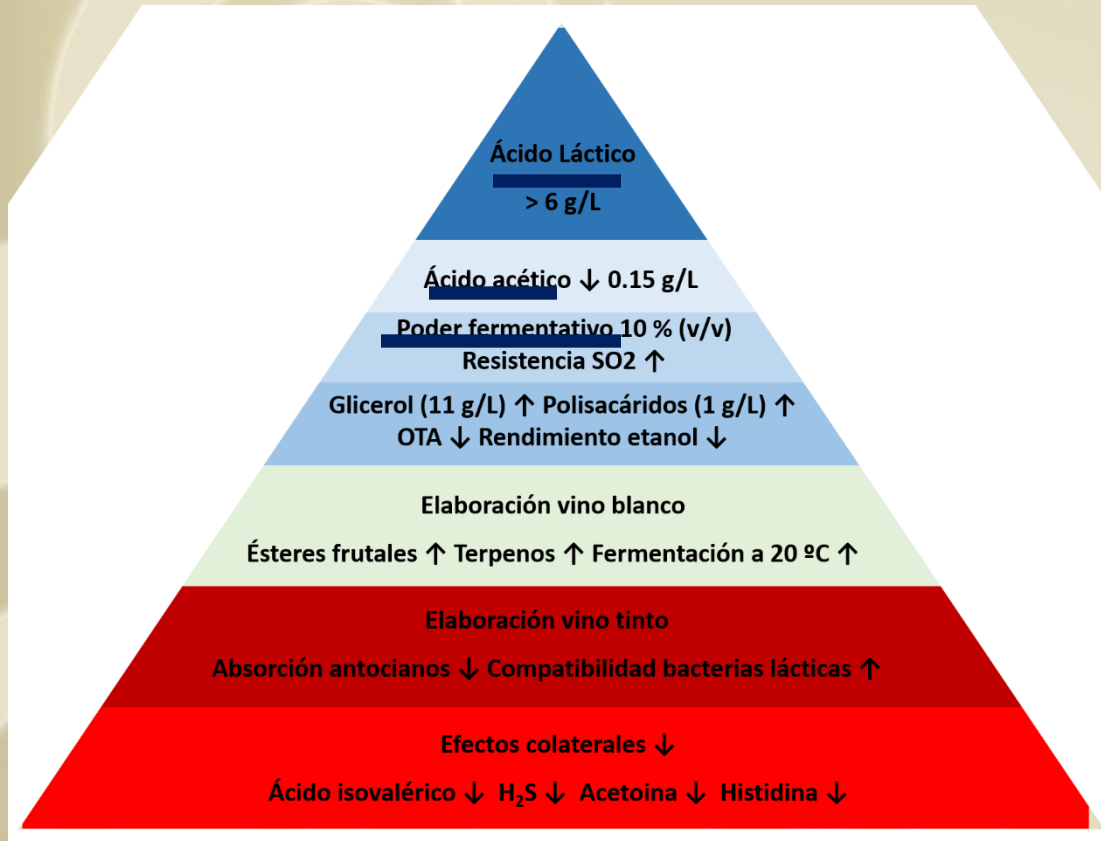
Vicente J; Navascués E; Calderón F; Santos A; Marquina D; Benito S (2021) An Integrative View of the Role of *Lachancea thermotolerans* in Wine Technology. Foods.

<https://www.mdpi.com/2304-8158/10/11/2878/htm>

Problemática viñedo español

Posibles Soluciones a la falta de acidez

Nuevos criterios de selección *Lachancea thermotolerans*



Adaptado de:

Benito S (2018) The impacts of *Lachancea thermotolerans* yeast strains on winemaking. Appl Microbiol Biotechnol 102: 6775–6790.

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Applied Microbiology and Biotechnology (2018) 102:6775–6790
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MINI-REVIEW



The impacts of *Lachancea thermotolerans* yeast strains on winemaking

Santiago Benito¹

Received: 8 April 2018 / Revised: 17 May 2018 / Accepted: 18 May 2018 / Published online: 6 June 2018
© Springer-Verlag GmbH Germany, part of Springer Nature 2018

Abstract

At one time, *Saccharomyces* spp. yeasts were the only option for use in winemaking due to their unique abilities to metabolize all grape juice sugars to ethanol. However, during the previous decade, several commercial non-*Saccharomyces* yeast products appeared in the biotechnology market. Some of them have slowly begun to establish new enological resources to solve modern winemaking challenges in the new century. Among these challenges, acidification in the warm-growing regions is of great concern for improving wine quality from those areas, particularly in light of the predictions of serious climate change. This review explores one of the most popular commercialized non-*Saccharomyces* yeast options in warm viticultural regions, *Lachancea thermotolerans*, and its influences on wine quality parameters, such as lactic acid, ethanol, glycerol, volatile acidity, volatile profiles, isovaleric acid, mannoproteins, polysaccharides, color, anthocyanins, amino acids, and sensory perception.

Keywords *Lachancea thermotolerans* · Non-*Saccharomyces* · Volatile compounds · Lactic acid · Wine · Anthocyanin

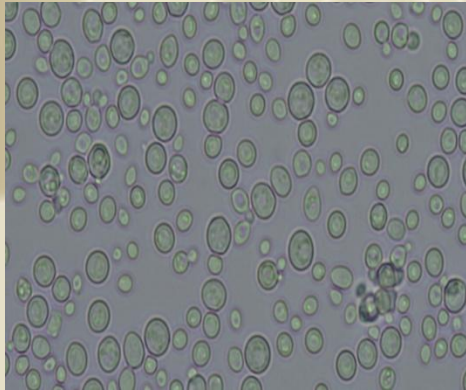
Nuevas tendencias:

Ácido málico, ácido succínico, OTA, alternativas SO₂ (chitosan), Resistencia SO₂, Adaptación ETOH. Uso combinado con *Schizosaccharomyces* o bacterias lácticas.

Nuevos criterios de selección *L. thermotolerans*

Además de ácido láctico ↑ =>

Ácido málico ↓ (tintos, estabilidad) + Ácido succínico ↑ (carácter mineral)



L. thermotolerans

f(cepa):

Á. málico ↓:

20-50%

Á succínico ↑:

Doble *S. cerevisiae*

Table 1

Final chemical analysis of pure fermentations in Synthetic Grape Must (SGM). The *Lachancea thermotolerans* strains used were NG-108, A11-612, MJ-311, BD-612, EM-119, L1, L3 (Complutense University of Madrid, Madrid, Spain), Concerto (CHR Hansen, Denmark), Excellence (X'Fresh Lamothe-Abiet, France), Laktia (Lallemand, Canada), Levulia Alcomeno (AEB Group, Italy), EnartisFerm QK (Enartis, Italy) and Octave (CHR Hansen, Denmark). The *Saccharomyces cerevisiae* control strain used was AWRI-796 (Maurivin, Australia).

Strain	Ethanol (%)	pH	Total Acidity (g/L)	Acetic Acid (g/L)	Malic Acid (g/L)	Lactic Acid (g/L)	Succinic Acid (g/L)	Glucose + Fructose (g/L)	Glycerol (g/L)
NG-108	8,02 ± 1,34c	3,43 ± 0,06bc	5,96 ± 0,85bc	0,1 ± 0,05b	1,95 ± 0,25abc	2,04 ± 1,03b	0,58 ± 0,05ab	67,77 ± 22,01ab	3,02 ± 0,08abcd
A11-612	8,59 ± 0,87c	3,24 ± 0,07d	9,01 ± 1,34a	0,14 ± 0,03b	1,39 ± 0,47d	5,18 ± 1,48a	0,72 ± 0,03a	57,27 ± 16,45b	3,07 ± 0,09ab
MJ-311	8,27 ± 0,58c	3,42 ± 0,02bc	6,08 ± 0,07bc	0,08 ± 0,04b	2,08 ± 0,03ab	1,99 ± 0,11b	0,6 ± 0,04a	63,49 ± 8,56ab	3,22 ± 0,25abc
BD-612	7,62 ± 0,74bc	3,43 ± 0,03bc	5,68 ± 0,47bc	0,04 ± 0,02b	2,05 ± 0,06ab	1,82 ± 0,55b	0,51 ± 0,05a	76,36 ± 13,34ab	2,82 ± 0,5abcd
EM-119	7,44 ± 0,65abc	3,43 ± 0,02bc	5,79 ± 0,5bc	0,08 ± 0,04b	2,09 ± 0,11ab	1,7 ± 0,53b	0,58 ± 0,03a	77,49 ± 9,5ab	3,32 ± 0,33a
L1	7,46 ± 0,78abc	3,36 ± 0,05cd	6,84 ± 0,77ab	0,12 ± 0,03b	1,87 ± 0,23bc	2,92 ± 1,02ab	0,59 ± 0,03a	76,14 ± 11,54ab	2,81 ± 0,18cd
L3	7,51 ± 0,59abc	3,34 ± 0,03cd	6,46 ± 0,6ab	0,12 ± 0,03b	2,01 ± 0,15abc	2,63 ± 0,63b	0,58 ± 0,04a	77,19 ± 10,44ab	2,81 ± 0,23abcd
Concerto	7,47 ± 0,61abc	3,49 ± 0,04ab	4,62 ± 0,11c	0,09 ± 0,03b	2,34 ± 0,15ab	0,62 ± 0,17c	0,42 ± 0,04bcd	77,45 ± 11,46ab	3,31 ± 0,31a
Excellence	8,12 ± 0,40c	3,31 ± 0,04bcd	6,92 ± 0,77ab	0,21 ± 0,02b	1,96 ± 0,18bcd	3,22 ± 0,83ab	0,56 ± 0,08abc	66,31 ± 6,61ab	2,49 ± 0,24d
Laktia	7,38 ± 1,15abc	3,46 ± 0,06ab	5,2 ± 0,49bc	0,18 ± 0,07b	2,4 ± 0,17ab	1,18 ± 0,64bc	0,58 ± 0,06ab	78,45 ± 18,21ab	3,23 ± 0,39abc
Levulia Alcomeno	6,26 ± 0,41a	3,40 ± 0,06bc	6,53 ± 0,02bc	0,12 ± 0,05b	2,04 ± 0,11bcd	2,49 ± 0,25b	0,52 ± 0,04cd	96,16 ± 5,45a	2,65 ± 0,35d
EnartisFerm QK	6,45 ± 0,9ab	3,31 ± 0,05cd	6,97 ± 1,41ab	0,12 ± 0,04b	1,76 ± 0,4cd	3,13 ± 1,37ab	0,65 ± 0,05a	91,3 ± 12,92ab	2,65 ± 0,02bcd
Octave	7,64 ± 0,10bc	3,50 ± 0,07ab	4,75 ± 0,25c	0,17 ± 0,04b	2,5 ± 0,12ab	0,55 ± 0,05c	0,57 ± 0,03abc	72,93 ± 1,11ab	3,36 ± 0,39abc
AWRI-796	11,26 ± 0,61d	3,56 ± 0,04a	4,47 ± 0,09c	0,55 ± 0,02a	2,48 ± 0,07a	0,03 ± 0,04d	0,3 ± 0,03d	17,28 ± 9,38c	3,68 ± 0,2a

Results are mean ± SD of three replicates. Different letters indicate statistical significance between groups.

Vicente, J., Vladic, L., Navascués, E., Brezina, S., Santos, A., Calderón, F., Tesfaye, W., Marquina, D., Rauhut, D., & Benito, S. (2024). A comparative study of *Lachancea thermotolerans* fermentative performance under standardized wine production conditions. Food Chemistry: X, 101214.

<https://www.sciencedirect.com/science/article/pii/S2590157524001019>

Nuevos criterios de selección *L. thermotolerans*

Uso combinado con quitosano => ácido láctico ↑

**Chitosan =>
Metabolismo de
producción de
Ácido Láctico ↑
20-40 %**

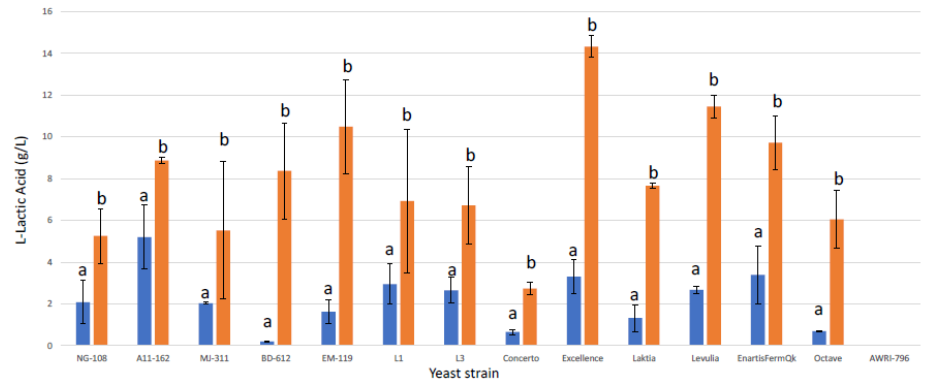


Figure 4. The final L-lactic acid concentrations (g/L) of the final wines fermented by the examined yeast strains are illustrated, indicating their fermentation in chitosan-free SGM (blue) and chitosan-enriched SGM (orange). Distinct letters are used to indicate statistically significant differences at a significance level of $p = 0.05$.



Vicente, J., Manea, P. P., Benito, S., Marquina, D., Kelanne, N., Yang, B., & Santos, A. (2024). *Lachancea thermotolerans* fermentative metabolism is enhanced by chitosan under winemaking conditions. LWT, 115863.

<https://www.sciencedirect.com/science/article/pii/S0023643824001427>

Vicente, J., Vladic, L., Marquina, D., Brezina, S., Rauhut, D., & Benito, S. (2024). The Influence of Chitosan on the Chemical Composition of Wines Fermented with *Lachancea thermotolerans*. Foods, 13(7), 987.

<https://www.mdpi.com/2304-8158/13/7/987>

Nuevos criterios de selección *L. thermotolerans*

Reducción de Ocratoxina A. Muy cepa-dendiente.
No correlacionado con la producción de ácido láctico.

OTA ↓ => 80-90 %

Efectos colaterales:

Color ↓ e IPT ↓

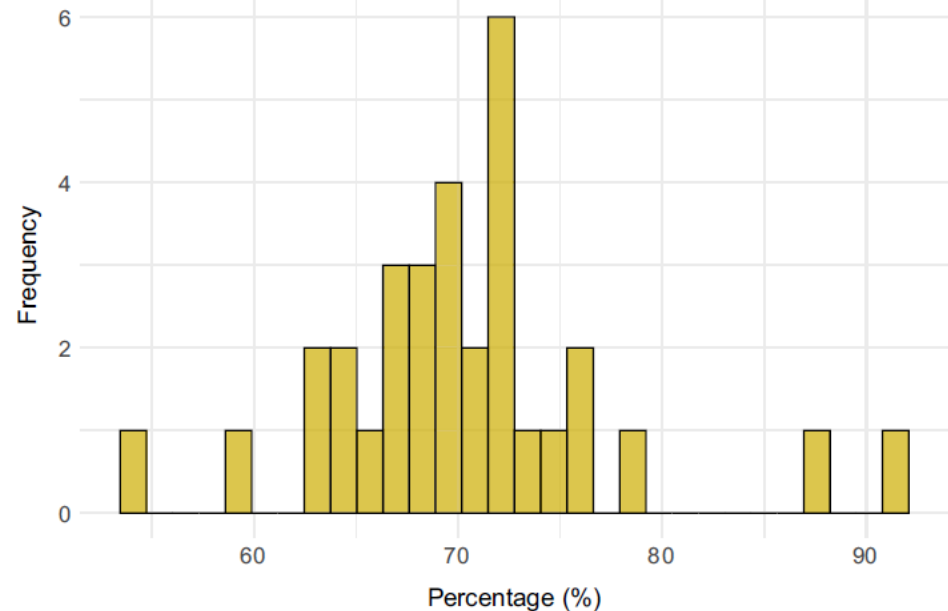


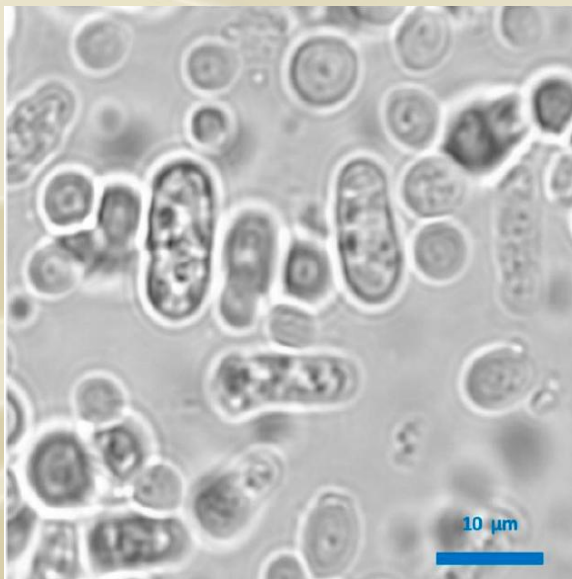
Fig. 5 Histogram for the mean values of ochratoxin A reduction (%) for the 32 studied *L. thermotolerans* strains after alcoholic fermentation

Vicente, J., Vidal, D., Tesfaye, W., Calderón, F., García, F. and Benito, S., 2025. Ochratoxin A reduction in wine fermentation: evaluating the potential of *Lachancea thermotolerans*. *AMB Express*, 15(1), p.90.

<https://link.springer.com/article/10.1186/s13568-025-01896-4>

Nuevas combinaciones con *L. thermotolerans*

Uso combinado *Lachancea thermotolerans* y *Schizosaccharomyces pombe*



microorganisms



Review

Combined Use of *Lachancea thermotolerans* and *Schizosaccharomyces pombe* in Winemaking: A Review

Santiago Benito 

Department of Chemistry and Food Technology, Polytechnic University of Madrid, Ciudad Universitaria S/N, 28040 Madrid, Spain; santiago.benito@upm.es; Tel.: +34-913-363-710 or +34-913-363-984

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Abstract: The combined use of *Lachancea thermotolerans* and *Schizosaccharomyces pombe* is a new winemaking biotechnology that aims to solve some modern industrial oenology problems related to warm viticulture regions. These areas are characterized for producing musts with high levels of sugar that can potentially be converted into wines with elevated ethanol contents, which are usually associated with high pH levels. This biotechnology was reported for the first time in 2015, and since then, several scientific articles have been published regarding this topic. These reported scientific

Benito S (2020) Combined use of *Lachancea thermotolerans* and *Schizosaccharomyces pombe* in winemaking: A review. *Microorganisms* 8: 655.

<https://www.mdpi.com/2076-2607/8/5/655>

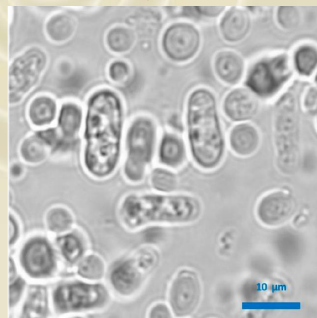
ALTERNATIVA INDUSTRIAL PROPUESTA



Mosto de uva

L. thermotolerans
AZÚCARES

S. pombe
AZÚCARES
ÁCIDO MÁLICO



ALCOHOL
A. LÁCTICO

ALCOHOL
ALCOHOL

2 Levaduras: *L. thermotolerans* + *S. pombe*

Únicamente 1º Fermentación



Vino estabilizado



Se evitan posibles efectos colaterales relacionados con Bacterias Lácticas de carácter heterofermentativo

- Pérdida color ↓ + Acidez volátil ↓
- Aminas Biógenas ↓ + Carbamato de Etilo ↓

Mientras se incrementa la acidez y disminuye el pH

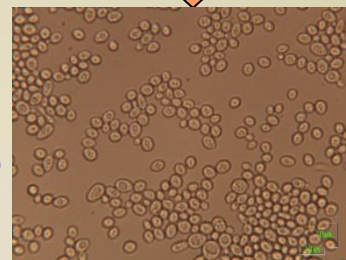
SIMPLIFICACIÓN MICROBIOLÓGICA



Mosto de uva

AZÚCARES

ALCOHOL

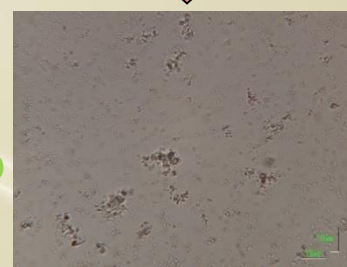


Levadura: *S. cerevisiae*

1º Fermentación

ÁCIDO
MÁLICO

ÁCIDO
LÁCTICO



Bacteria Láctica : *O. oeni*

2º Fermentación



Vino estabilizado



Otras posibles combinaciones de *L. thermotolerans*:

Table 4. Summary of the main *L. thermotolerans* combinations in winemaking during alcoholic fermentation, explaining their enological impact, advantages, and disadvantages.

Combined Species	Enological Impact	Advantages	Disadvantages
<i>Saccharomyces cerevisiae</i> Benito et al., 2018 [2]	Increase in acidification	pH reductions down to 0.5; ethanol reduction down to 1.6% (v/v)	Red wines need to perform malolactic fermentation after alcoholic fermentation
<i>Schizosaccharomyces pombe</i> Benito et al., 2020 [19]	Increase in acidification by <i>L. thermotolerans</i> ; malic acid stabilization during alcoholic fermentation by <i>S. pombe</i>	Reduction in production hours; color increase; ethanol reduction down to 3% (v/v); biogenic amines control; ethyl carbamate control	<i>S. pombe</i> strain must be selected to produce low levels of acetic acid and sulphidric acid
<i>Oenococcus oeni</i> Snyder et al., 2021; Benito et al., 2021 [15,20]	Increase in acidification by <i>L. thermotolerans</i> ; malic acid stabilization during alcoholic fermentation by <i>O. oeni</i>	Reduction in production hours; increase in color	Risk of an increase in acetic acid; inhibition of yeast development; biogenic amines production; ethyl carbamate production
<i>Lactiplantibacillus plantarum</i> Benito et al., 2021 [20]	Increase in acidification by <i>L. thermotolerans</i> ; malic acid stabilization during alcoholic fermentation by <i>L. plantarum</i>	Reduction in production hours; increase in color; biogenic amines control; ethyl carbamate control	Limited capacity in very acid wines; compatibility between strains of <i>L. plantarum</i> and <i>L. thermotolerans</i>
Other non- <i>Saccharomyces</i> Hranilovic et al., 2018; Escribano et al., 2021; Vaquero et al., 2021 [21,51,67]	Additional value different from acidification	Aroma complexity; increase in glycerol; ethanol reduction; synergy	Low fermentative power of most non- <i>Saccharomyces</i> .



Review

An Integrative View of the Role of *Lachancea thermotolerans* in Wine Technology

Javier Vicente¹, Eva Navascués^{2,3}, Fernando Calderón¹, Antonio Santos¹, Domingo Marquina⁴ and Santiago Benito^{1*}

¹ Unit of Microbiology, Genetics, Physiology and Microbiology Department, Biology Faculty, Complutense University of Madrid, Ciudad Universitaria S/N, 28040 Madrid, Spain; jervicente@ucm.es (J.V.); anavascu@ucm.es (E.N.); fernando.calderon@ucm.es (F.C.); antonio.santos@ucm.es (A.S.); dominico.marquina@ucm.es (D.M.); santiago.benito@ucm.es (S.B.)
² Department of Chemistry and Food Technology, Polytechnic University of Madrid, Ciudad Universitaria S/N, 28040 Madrid, Spain; eira.navascues@upm.es (E.N.); fernando.calderon@upm.es (F.C.)
³ Page de Carreteras, Camino de Casareque, 16, 47001 Valladolid, Spain
⁴ Correspondence: santiago.benito@ucm.es; Tel.: +34-913-363-370 or +34-913-363-336

Abstract: The interest in *Lachancea thermotolerans*, a yeast species with unusual characteristics, has notably increased in all ecological, evolutionary, and industrial aspects. One of the key characteristics of *L. thermotolerans* is the production of high quantities of lactic acid compared to other yeast species. Its evolution has mostly been driven by the influence of the environment and domestication, allowing several metabolic traits to arise. The molecular regulation of the fermentative process in *L. thermotolerans* shows interesting routes that play a complementary or protective role against fermentative stresses. One route that is activated under this condition is involved in the production of lactic acid, presenting a complete system for its production, showing the involvement of several enzymes and transporters. In winemaking, the use of *L. thermotolerans* is nowadays mostly focused in early-mustification grape varieties, in which over-ripening can produce wines lacking acidity and with high concentrations of ethanol. Recent studies have reported new positive influences on quality apart from lactic acid acidification, such as improvements in color, glutathione production, aroma, malic acid, polysaccharides, or specific enzymatic activities that contribute introducing new criteria for selecting better strains. This positive influence on winemaking has increased the availability of commercial strains during recent years, allowing comparisons among some of those products. Initially, the management of *L. thermotolerans* was thought to be with *Saccharomyces cerevisiae* to properly and alcoholic fermentation, but new studies are innovating and reporting combinations with other key enological microorganisms such as *Schizosaccharomyces pombe*, *Oenococcus oeni*, *Lactiplantibacillus plantarum*, or other non-*Saccharomyces*.

Keywords: *Lachancea thermotolerans*; lactic acid; wine; acidity; volatile; evolution; transcription; metabolism regulation; lactate dehydrogenase enzymes

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Check for updates

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Article

The Combined Use of *Lachancea thermotolerans* and *Lactiplantibacillus plantarum* (former *Lactobacillus plantarum*) in Wine Technology

Ángel Urbina, Fernando Calderón and Santiago Benito *

¹ Department of Chemistry and Food Technology, Polytechnic University of Madrid, University City, 28040 Madrid, Spain; angel.urbina@upm.es (Á.U.); fernando.calderon@upm.es (F.C.)
 * Correspondence: santiago.benito@upm.es; Tel.: +34-913-363-370

Abstract: Most commercialized red wines are produced through alcoholic fermentation performed by yeasts of the *Saccharomyces* genus, and a second fermentation performed by lactic bacteria of the *Oenococcus* spp. species once the first is completely finished. However, the classical process can suffer complications, of which the risks can increase in grape juices with high contents of sugar and pH. Due to climate change, these situations are becoming more common in the winemaking industry. The main risks in these scenarios are alcoholic fermentation stops or sluggish and undesirable bacteria development while alcoholic fermentation is not finished yet and wine still contains residual sugars. The study propose a novel alternative that offers a solution or reduces the risk of those scenarios while increasing acidity, which is another serious problem of warm viticulture regions. The alternative consists of the combined use of *Lachancea thermotolerans* to reduce the pH of musts that suffer from a lack of acidity, *Lactiplantibacillus plantarum* (former *Lactobacillus plantarum*) to achieve malic acid stability during the first stages of alcoholic fermentation, and *Saccharomyces* to complete the alcoholic fermentation in difficult wines of high potential alcohol degree or over 15% (v/v). The new proposed biotechnology produced wines with higher final concentrations in lactic acid, glycerol, color intensity, ethyl lactate and 2-phenyl ethyl acetate in 2.39 g/L, 0.52 g/L, 21%, 48% and 37% respectively than the classical methodology where *Saccharomyces* genus performs alcoholic fermentation and later *Oenococcus* spp. performs malolactic fermentation. Additionally, the new alternative produced wines with lower concentration in ethanol, pH, acetic acid, ethyl acetate, diacetyl and 1-propanol (0.337% (v/v), 0.26, 0.08 g/L, 22%, 49% and 28% respectively than the classic method.

Keywords: *Lachancea thermotolerans*; *Lactiplantibacillus plantarum*; *Lactobacillus plantarum*; *Saccharomyces*; *Oenococcus* spp.; malic acid; lactic acid

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Citation: Urbina Á, Calderón F, Benito S. The Combined Use of *Lachancea thermotolerans* and *Lactiplantibacillus plantarum* (former *Lactobacillus plantarum*) in Wine Technology. *Foods* 2021; 10: 1356. <https://doi.org/10.3390/foods10031356>

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journal homepage: www.elsevier.com/locate/ijfoodmicro



Review

Biological management of acidity in wine industry: A review

Javier Vicente^a, Yasemin Baran^b, Eva Navascués^{a,c}, Antonio Santos^a, Fernando Calderón^a, Domingo Marquina^a, Doris Rauhut^b, Santiago Benito^{a,*}

^a Unit of Microbiology, Genetics, Physiology and Microbiology Department, Biology Faculty, Complutense University of Madrid, Ciudad Universitaria, S/N, 28040 Madrid, Spain
^b Department of Microbiology and Biochemistry, Hochschule Göttingen University (HGZ), Von-Lado-Strasse 1, 65366 Göttingen, Germany
^c Department of Chemistry and Food Technology, Polytechnic University of Madrid, Ciudad Universitaria, S/N, 28040 Madrid, Spain
^d Page de Carreteras, Camino de Casareque, 16, 47001 Valladolid, Spain

ARTICLE INFO

Keywords:

Biological de-acidification
 Biological acidification
 Alternative strategies
Lachancea thermotolerans
Oenococcus oeni
Lactiplantibacillus plantarum
Lactobacillus plantarum
Schizosaccharomyces pombe
Saccharomyces cerevisiae

ABSTRACT

Climate change is generating several problems in wine technology. One of the main ones is lack of acidity and difficulties performing malolactic fermentation to stabilize wines before bottling. Among the different available acidity management technologies, such as direct acid addition, ion exchange resins, electro-membrane treatments, or vineyard management, the microbiological option is reliable and deeply studied. The main approach is the increase in malic acid content because of the metabolism of specific *Saccharomyces* strains and to increase lactic acid because of the metabolism of *Lachancea* genus. Other non-*Saccharomyces* yeasts, such as *Schizosaccharomyces* or *Candida* spp. can also acidify significantly because of the production of pyruvic or succinic acid. Wine industry needs the removal of malic acid in most red wines before bottling to achieve wine stability. *Oenococcus* spp. performs the malolactic fermentation of red wines on most conditions because of the metabolism of malic acid into lactic acid. However, modern oenology challenges such as high ethanol concentrations, high pH or low levels of malic acid have made researchers to look for other options to reduce potential risks of deviation. Other wine-related microorganisms able to de-acidify malic acid have appeared as interesting alternatives for specific different scenarios. *Lactiplantibacillus plantarum* and *Schizosaccharomyces* genus make up nowadays the main studied alternatives.

Otras posibles combinaciones de *L. thermotolerans*:

Table 4. Summary of the main *L. thermotolerans* combinations in winemaking during alcoholic fermentation, explaining their enological impact, advantages, and disadvantages.

Combined Species	Enological Impact	Advantages	Disadvantages
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<i>Schizosaccharomyces pombe</i> Benito et al., 2020 [19]	Increase in acidification by <i>L. thermotolerans</i> ; malic acid stabilization during alcoholic fermentation by <i>S. pombe</i>	Reduction in production hours; color increase; ethanol reduction down to 3% (<i>v/v</i>); biogenic amines control; ethyl carbamate control	<i>S. pombe</i> strain must be selected to produce low levels of acetic acid and sulphidric acid
<i>Oenococcus oeni</i> Snyder et al., 2021; Benito et al., 2021 [15,20]	Increase in acidification by <i>L. thermotolerans</i> ; malic acid stabilization during alcoholic fermentation by <i>O. oeni</i>	Reduction in production hours; increase in color	Risk of an increase in acetic acid; inhibition of yeast development; biogenic amines production; ethyl carbamate production
<i>Lactiplantibacillus plantarum</i> Benito et al., 2021 [20]	Increase in acidification by <i>L. thermotolerans</i> ; malic acid stabilization during alcoholic fermentation by <i>L. plantarum</i>	Reduction in production hours; increase in color; biogenic amines control; ethyl carbamate control	Limited capacity in very acid wines; compatibility between strains of <i>L. plantarum</i> and <i>L. thermotolerans</i>
Other non- <i>Saccharomyces</i> Hranilovic et al., 2018; Escribano et al., 2021; Vaquero et al., 2021 [21,51,67]	Additional value different from acidification	Aroma complexity; increase in glycerol; ethanol reduction; synergy	Low fermentative power of most non- <i>Saccharomyces</i> .



Urbina Á, Calderón F, Benito S (2021) The Combined Use of *Lachanea thermotolerans* and *Lactiplantibacillus plantarum* (former *Lactobacillus plantarum*) in Wine Technology. Foods 10: 1356. <https://www.mdpi.com/2304-8158/10/6/1356>

Vicente, J., Wang, L., Brezina, S., Fritsch, S., Navascués, E., Santos, A., Calderón, F., Tesfaye, W., Marquina, D., Rauhut, D. and Benito, S., (2024). Enhancing wine fermentation through concurrent utilization of *Lachanea thermotolerans* and lactic acid bacteria (*Oenococcus oeni* and *Lactiplantibacillus plantarum*) or *Schizosaccharomyces pombe*. Food Chemistry: X, 24, p.102054.

<https://www.sciencedirect.com/science/article/pii/S2590157524009428>

Nuevas combinaciones con *L. thermotolerans*

L. thermotolerans x bacterias lácticas



Article The Combined Use of *Lachancea thermotolerans* and *Lactiplantibacillus plantarum* (former *Lactobacillus plantarum*) in Wine Technology

Ángel Urbina, Fernando Calderón and Santiago Benito

Department of Chemistry and Food Technology, Polytechnic University of Madrid, University City, 28002 Madrid, Spain; angel.urbina@upm.es (Á.U.); fernando.calderon@upm.es (F.C.)
* Correspondence: santiago.benito@upm.es; Tel.: +34-913-363-701

Abstract: Most commercialized red wines are produced through alcoholic fermentation performed by yeasts of the *Saccharomyces* genus, and a second fermentation performed by lactic bacteria of the *Oenococcus* oeni species once the first is completely finished. However, the classical process can suffer complications, of which the risks can increase in grape juices with high contents of sugar and pH. Due to climate change, these situations are becoming more common in the winemaking industry. The main risks in these situations are alcoholic fermentation stops or sluggish and undesirable bacteria development while alcoholic fermentation is not finished yet and wine still contains residual sugars. The study propose a novel alternative that offers a solution or reduces the risk of those situations while increasing acidity, which is another serious problem of warm viticultural regions. The alternative consists of the combined use of *Lachancea thermotolerans* to reduce the pH of musts that suffer from a lack of acidity. *Lactiplantibacillus plantarum* (formerly *Lactobacillus plantarum*) to achieve malic acid stability during the first stages of alcoholic fermentation, and *Saccharomyces bayanus* to complete the alcoholic fermentation in difficult wines of high potential alcohol degree of over 15% (v/v). The new proposed biotechnology produced wines with higher final concentrations in lactic acid, glycerol, color intensity, ethyl lactate and 2-phenylethyl acetate in 2.39 g/L, 0.78 g/L, 23%, 48% and 57% respectively than the classical methodology where *Saccharomyces* genus performs alcoholic fermentation and later *Oenococcus* oeni performs malolactic fermentation. Additionally, the new alternative produced wines with lower concentration in ethanol, pH, acetic acid, ethyl acetate, diacetyl and 1-pentanol in 0.37% (v/v), 0.26, 0.09 g/L, 22%, 48% and 28% respectively than the classic method.

Keywords: *Lachancea thermotolerans*; *Lactiplantibacillus plantarum*; *Lactobacillus plantarum*; *Saccharomyces bayanus*

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Review

Biological management of acidity in wine industry: A review

Javier Vicente^a, Yasemin Baran^a, Eva Navascués^a, Antonio Santos^a, Fernando Calderón^a, Domingo Marquina^a, Doris Rauhut^b, Santiago Benito^{a,*}

^a Department of Microbiology, Genetics, Physiology and Microbiology Department, Biology Faculty, Complutense University of Madrid, Ciudad Universitaria, S/N, 28040 Madrid, Spain
^b Department of Microbiology and Biotechnology, Hochschule Göttingen University (HGZ), Von-Liebig-Strasse 1, 37060 Göttingen, Germany
^c Department of Chemistry and Food Technology, Polytechnic University of Madrid, Ciudad Universitaria, S/N, 28040 Madrid, Spain
^d Dept. de Ciències, Centre de Ciències, S/N, 47100 Valladolid, Spain

ARTICLE INFO

Keywords:
Biological de-acidification
Biological stabilization
Alcoholic fermentation
Lachancea thermotolerans
Oenococcus oeni
Lactiplantibacillus plantarum
Lactobacillus plantarum
Schizosaccharomyces pombe
Saccharomyces cerevisiae

ABSTRACT

Climate change is generating several problems in wine technology. One of the main ones is lack of acidity and difficulties performing malolactic fermentation to stabilize wines before bottling. Among the different available acidity management techniques, such as direct acid addition, ion exchange resins, short-chain fatty acids, or yeast management, the microbiological option is viable and deeply studied. The main approach is the increase in malic acid content because of the metabolism of specific *Saccharomyces* strains and to increase lactic acid because of the metabolism of *Lachancea* genus. Other non-*Saccharomyces* yeasts, such as *Stremmeniella* *lactiflora* or *Candida* *glabrata* can also acidity significantly because of the production of glyceric or succinic acid. Wine industry needs the removal of malic acid in most red wines before bottling to achieve wine stability. *Oenococcus* oeni performs the malolactic fermentation of red wines on most conditions because of the metabolism of malic acid into lactic acid. However, modern wineries challenge with high ethanol concentrations, high pH or low levels of malic acid have made researchers to look for other options to reduce potential risks of deviation. Other wine-related microorganisms able to de-acidify malic acid have appeared in interesting alternatives to specific difficult scenarios. *Lactiplantibacillus plantarum* and *Schizosaccharomyces pombe* make up nowadays the main studied alternatives.

Food Chemistry: X 24 (2024) 102054

Contents lists available at ScienceDirect

Food Chemistry: X

journal homepage: www.sciencedirect.com/journal/food-chemistry-x

Enhancing wine fermentation through concurrent utilization of *Lachancea thermotolerans* and lactic acid bacteria (*Oenococcus oeni* and *Lactiplantibacillus plantarum*) or *Schizosaccharomyces pombe*

Javier Vicente^a, Li Wang^{b,c}, Silvia Brezina^a, Stefanie Fritsch^b, Eva Navascués^a, Antonio Santos^a, Fernando Calderón^a, Wendu Tesfaye^a, Doris Rauhut^b, Santiago Benito^{a,*}

^a Dept. de Microbiología, Genética, Fisiología y Microbiología, Facultad Biología, Complutense University of Madrid, Ciudad Universitaria, S/N, 28040 Madrid, Spain
^b Department of Microbiology and Biotechnology, Hochschule Göttingen University (HGZ), Von-Liebig-Strasse 1, 37060 Göttingen, Germany
^c Department of Chemistry and Food Technology, Polytechnic University of Madrid, Ciudad Universitaria, S/N, 28040 Madrid, Spain

ARTICLE INFO

Chemical compound studied in this article:
L. lactis and *PhaChen* (20220000)
Acetic acid and *PhaChen* (20220000)
Acetic acid and *PhaChen* (20220000)
Acetic acid and *PhaChen* (20220000)
Phenylethyl alcohol and *PhaChen* (20220000)
Phenylethyl alcohol and *PhaChen* (20220000)

Keywords:
Lachancea thermotolerans
Oenococcus oeni
Lactiplantibacillus plantarum
Lactobacillus plantarum
Saccharomyces bayanus
Schizosaccharomyces pombe
Malic acid
Lactic acid

ABSTRACT

Most commercially available red wines undergo alcoholic fermentation by *Saccharomyces* yeasts, followed by a second fermentation with the lactic acid bacteria *Oenococcus* oeni once the initial process is complete. However, this traditional approach can encounter complications in specific scenarios. These situations pose risks such as stalled alcoholic fermentation or the growth of undesirable bacteria while the process remains incomplete, leaving residual sugars in the wine. To address these challenges and the use of low acidity prevalent in warmer viticultural regions, several novel alternatives are available. The alternatives involve the combined use of *Lachancea thermotolerans* to increase the acidity of the musts, lactic acid bacteria (*Oenococcus* oeni and *Lactiplantibacillus plantarum*) to ensure malic acid stability during early alcoholic fermentation stages, and *Saccharomyces cerevisiae* to properly complete alcoholic fermentation. The study showed variations in the final chemical parameters of wines based on the microorganisms used.

Urbina Á, Calderón F, Benito S (2021) The Combined Use of *Lachancea thermotolerans* and *Lactiplantibacillus plantarum* (former *Lactobacillus plantarum*) in Wine Technology. Foods 10: 1356.

<https://www.mdpi.com/2304-8158/10/6/1356>

Vicente J; Baran Y; Navascués E; Santos A; Calderón F; Marquina D; Rauhut D; Benito S (2023) Biology management of acidity in wine industry: A review. Int J Food Microbiol.

<https://www.sciencedirect.com/science/article/pii/S0168160522001982>

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<https://www.sciencedirect.com/science/article/pii/S2590157524009428>

ALTERNATIVA INDUSTRIAL PROPUESTA

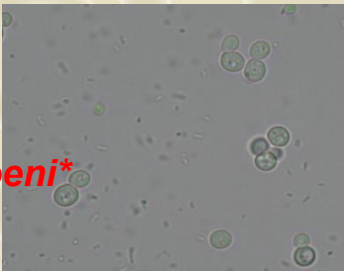


Mosto de uva

Inicio Fermentación alcohólica

L. thermotolerans
AZÚCARES

L. Plantarum o *O. oeni**
ÁCIDO MÁLICO



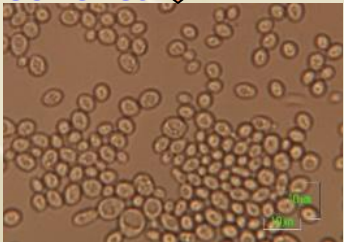
ALCOHOL
A. LÁCTICO

A. LÁCTICO

Fin Fermentación alcohólica

S. cerevisiae

AZÚCARES



ALCOHOL

Únicamente 1º Fermentación



Vino estabilizado



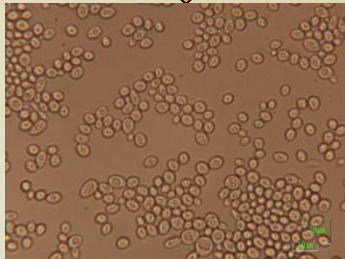
Se evitan posibles efectos colaterales relacionados con Bacterias Lácticas de carácter heterofermentativo
- Pérdida color ↓ + Acidez volátil ↓
Mientras se incrementa la acidez y disminuye el pH

SIMPLIFICACIÓN MICROBIOLÓGICA



Mosto de uva

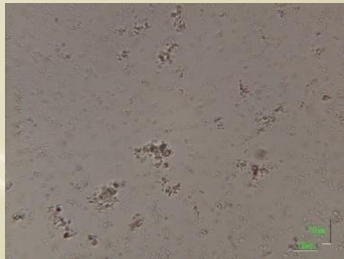
AZÚCARES



ALCOHOL

Levadura: *S. cerevisiae*

1º Fermentación



ÁCIDO MÁLICO

ÁCIDO LÁCTICO

Bacteria Láctica : *O. oeni*

2º Fermentación



Vino estabilizado



Conclusiones

- Primeros criterios de selección de *L. thermotolerans* => **ácido láctico** ↑, **ácido acético** ↓ y **poder fermentativo** ↑.
- Nuevos criterios de selección de *L. thermotolerans* => **ácido málico** ↓ (vinos tintos), **ácido succínico** ↑ (carácter mineral), **OTA** ↓, **resistencia SO2** y **adaptación a etanol**.
- Nuevos usos/combinaciones:
 - Combinación con **quitosano** => alternativa a SO2 + Á. láctico ↑
 - **Schizosaccharomyces** => Estabilización ácido málico (vinos tintos)
 - **Bacterias lácticas** => Estabilización ácido málico (vinos tintos)

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<https://link.springer.com/article/10.1007/s00253-014-6197-2>

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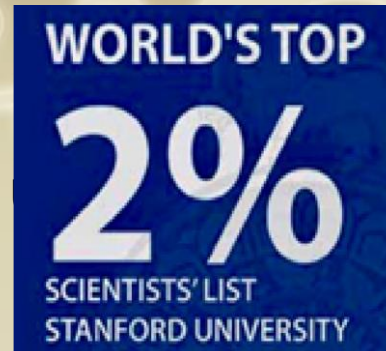
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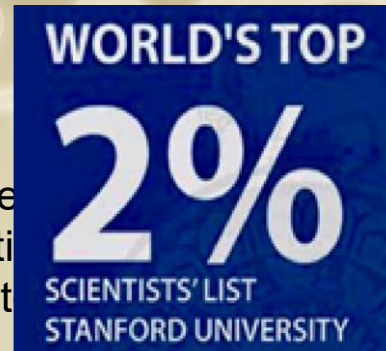
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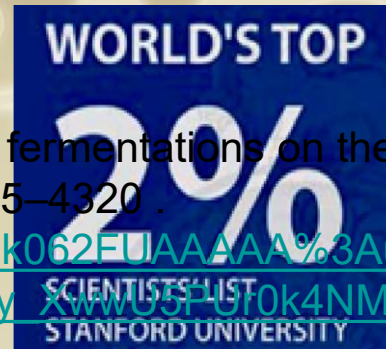
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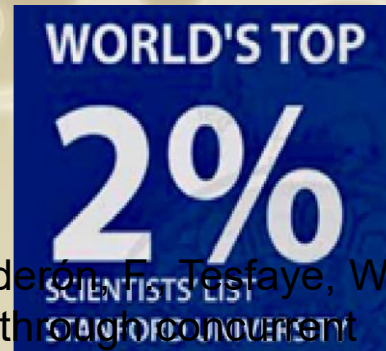
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