

Fruit beers: innovative protocols to produce craft beer by using Sicilian fruits and unconventional yeasts

Università degli Studi di Palermo – Dip. SAAF

Prof. Nicola FRANCESCA

nicola.francesca@unipa.it

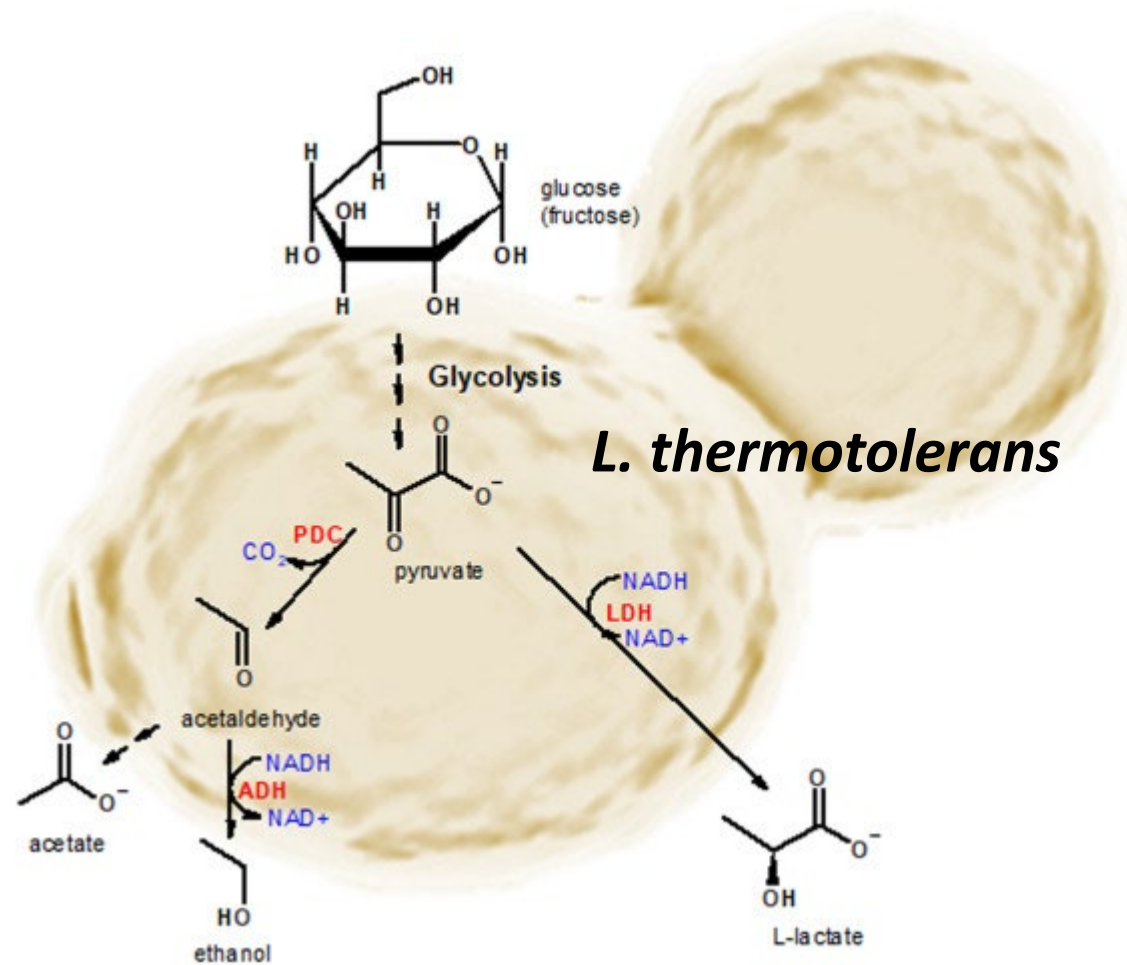
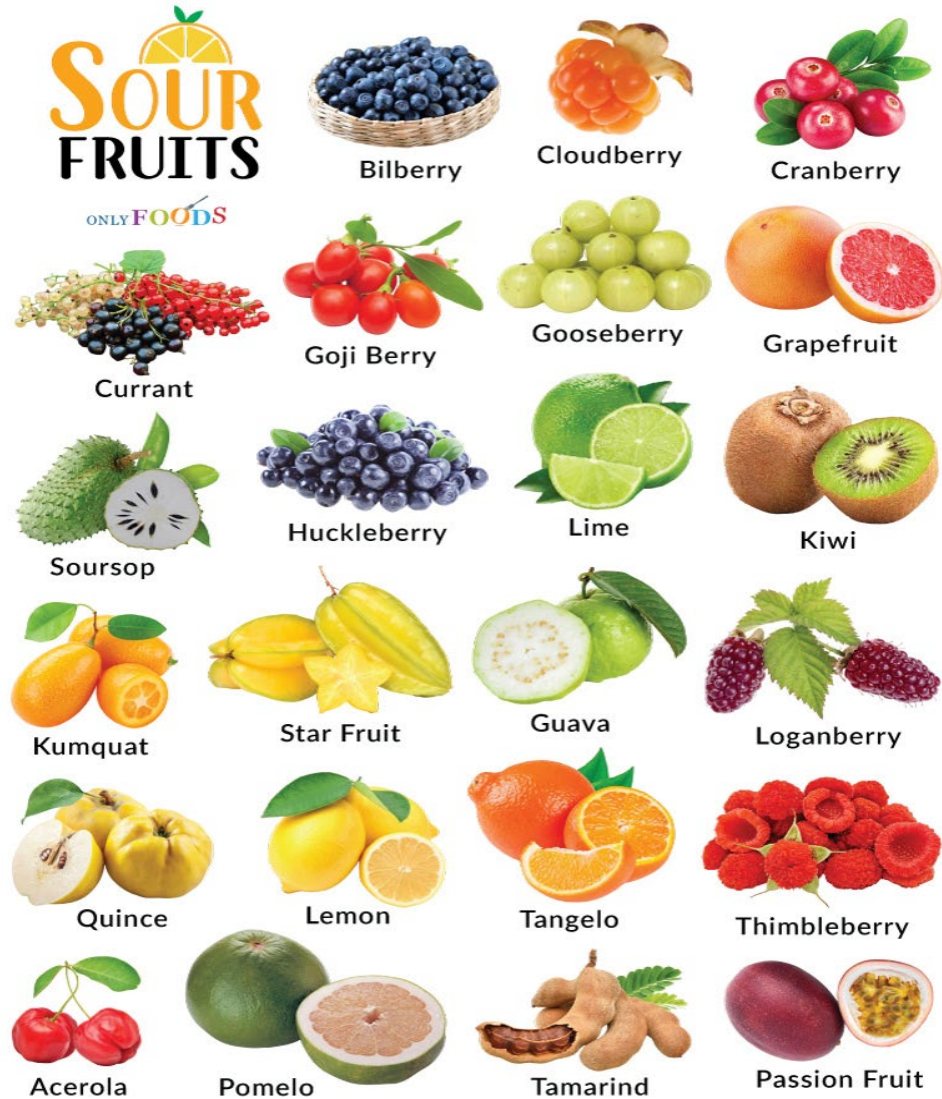
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Fruit Beers



Fruit Beers: the Sour Taste



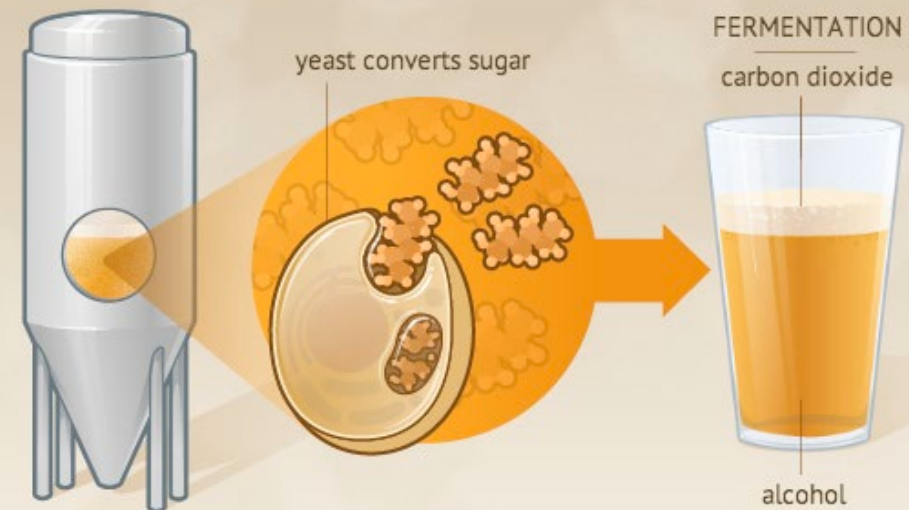
Low Ethanol + Fruit = Healthy?

Fruit Beers: when and how much?

The 8 Stages of Beer Making Process



HOW DID THEY FERMENT BEER?



Yeast Niches

High Sugar Content

Manna ash

Honey and Apiculture Products



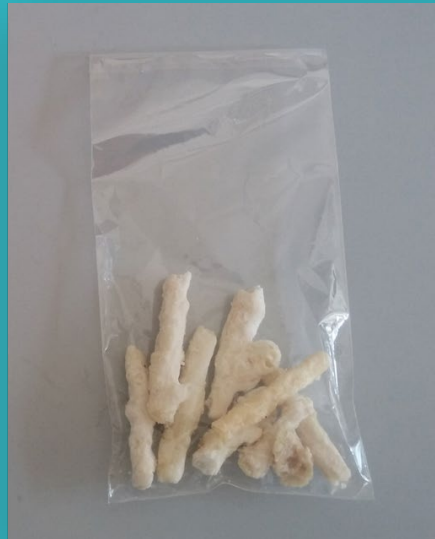
SUGAR

MANNOSIUM 30%
MANNOTRIOSE 30%
FRUCTOSE 30%

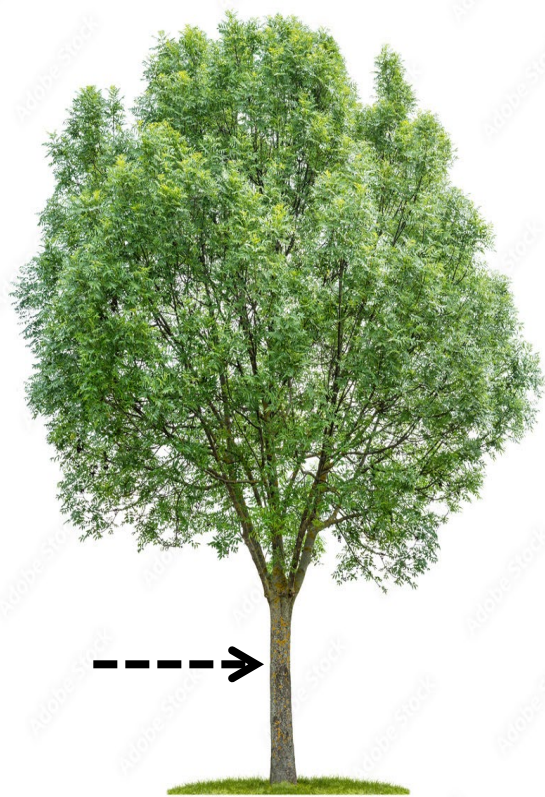
SUGARS 80%
GLUCOSE 50%
FRUCTOSE 50%

Manna

Manna is the product of the solidification of the processed sap that emerges during the summer season from the incisions made in the stem and main branches of certain species of *Fraxinus* spp.



Fraxinus angustifolia





 **frontiers**
in Microbiology

ORIGINAL RESEARCH
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Insights Into the Cultivable Microbial Ecology of “Manna” Ash Products Extracted From *Fraxinus angustifolia* (*Oleaceae*) Trees in Sicily, Italy

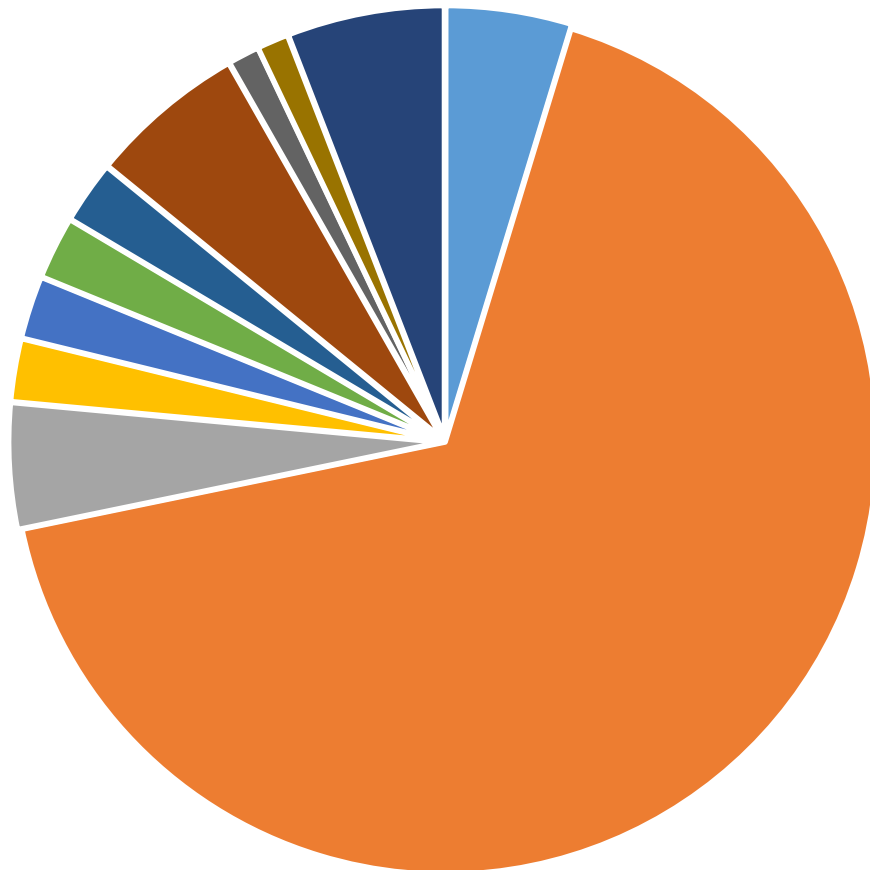
Rosa Guarcello, Raimondo Gaglio, Aldo Todaro, Antonio Alfonzo, Rosario Schicchi, Fortunato Cirlincione, Giancarlo Moschetti and Nicola Francesca*

Sample code	Source	Media								
		Bacteria					Yeasts		FF	
		PCA	GM17	DWA-b	VRBGA	RCM ^a	TGY	DWA-y	PDA	
1-10 Manna	Cannolo	n.d.	1.60 ± 0.2	n.d.	n.d.	n.d.	n.d.	n.d.	1.20 ± 0.1	
2-6 Manna	Cannolo	2.48 ± 0.2	n.d.	n.d.	n.d.	1.39	n.d.	n.d.	1.20 ± 0.1	
3-8 Manna	Cannolo	4.40 ± 0.2	1.70 ± 0.1	2.95 ± 0.3	n.d.	n.d.	n.d.	2.90 ± 0.5	n.d.	
4-11 Manna	Cannolo	2.00 ± 0.2	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	1.30 ± 0.1	
5-15 Manna	Cannolo	2.60 ± 0.4	2.00 ± 0.3	n.d.	n.d.	1.15	n.d.	2.48 ± 0.2	n.d.	
6-16 Manna	Cannolo	5.46 ± 0.5	2.15 ± 0.2	2.00 ± 0.3	1.48 ± 0.2	n.d.	n.d.	n.d.	n.d.	
7-10b Manna	Cannolo	2.15 ± 0.2	1.60 ± 0.2	n.d.	n.d.	n.d.	1.21 ± 0.1	n.d.	1.15 ± 0.1	
8-6b Manna	Cannolo	3.47 ± 0.3	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	1.24 ± 0.2	
9-11b Manna	Cannolo	2.11 ± 0.4	1.70 ± 0.1	n.d.	n.d.	1.21	n.d.	2.15 ± 0.4	n.d.	
10-15b Manna	Cannolo	3.26 ± 0.5	n.d.	1.95 ± 0.4	1.25 ± 0.3	n.d.	n.d.	n.d.	1.22 ± 0.1	
11-16b Manna	Cannolo	3.09 ± 0.4	2.00 ± 0.3	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	
12-10c Manna	Cannolo	2.35 ± 0.5	2.05 ± 0.3	n.d.	n.d.	1.08	n.d.	n.d.	1.20 ± 0.1	
13-6-1c Manna	Cannolo	2.49 ± 0.4	2.00 ± 0.1	2.14 ± 0.5	n.d.	n.d.	n.d.	2.22 ± 0.3	1.29 ± 0.2	
14-11c Manna	Cannolo	n.d.	n.d.	n.d.	n.d.	n.d.	1.18 ± 0.1	n.d.	n.d.	
15-15c Manna	Cannolo	n.d.	1.78 ± 0.3	1.55 ± 0.3	n.d.	n.d.	n.d.	2.18 ± 0.1	1.34 ± 0.3	
16-16c Manna	Cannolo	2.22 ± 0.2	1.15 ± 0.4	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	
17-5 Manna	Rottame	n.d.	n.d.	2.00 ± 0.3	n.d.	n.d.	n.d.	n.d.	2.50 ± 0.2	
18-7 Manna	Rottame	2.00 ± 0.3	n.d.	n.d.	n.d.	n.d.	2.60 ± 0.3	2.00 ± 0.1	n.d.	
19-12 Manna	Rottame	3.00 ± 0.3	2.04 ± 0.4	2.00 ± 0.3	n.d.	2.04	4.14 ± 0.2	4.23 ± 0.2	1.30 ± 0.1	
20-13 Manna	Rottame	3.18 ± 0.6	n.d.	2.78 ± 0.3	1.20 ± 0.1	1.59	2.78 ± 0.3	3.26 ± 0.4	1.60 ± 0.2	
21-17 Manna	Rottame	4.04 ± 0.2	2.86 ± 0.5	2.78 ± 0.3	n.d.	1.44	5.11 ± 0.4	5.30 ± 0.1	2.00 ± 0.1	
22-18 Manna	Rottame	3.89 ± 0.4	2.11 ± 0.1	3.56 ± 0.3	n.d.	n.d.	3.30 ± 0.7	4.48 ± 0.3	1.32 ± 0.1	
23-5b Manna	Rottame	n.d.	n.d.	n.d.	n.d.	1.20	3.20 ± 0.1	3.21 ± 0.1	n.d.	
24-7b Manna	Rottame	n.d.	n.d.	n.d.	n.d.	n.d.	4.21 ± 0.5	4.28 ± 0.2	2.22 ± 0.3	
25-12b Manna	Rottame	n.d.	n.d.	n.d.	n.d.	1.05	n.d.	5.00 ± 0.6	3.44 ± 0.5	
26-17b Manna	Rottame	n.d.	n.d.	n.d.	n.d.	0.1	2.22	2.66 ± 0.3	1.31 ± 0.1	1.44 ± 0.1
27-18b Manna	Rottame	n.d.	n.d.	n.d.	n.d.	1.59	3.44 ± 0.2	2.33 ± 0.1	n.d.	
28-5-1c Manna	Rottame	n.d.	n.d.	n.d.	n.d.	1.44	n.d.	3.37 ± 0.3	1.11 ± 0.3	
29-12d Manna	Rottame	n.d.	n.d.	n.d.	n.d.	n.d.	1.78 ± 0.4	4.74 ± 0.3	1.74 ± 0.2	
30-13c Manna	Rottame	n.d.	n.d.	n.d.	n.d.	n.d.	5.47 ± 0.4	5.11 ± 0.4	2.13 ± 0.1	
31-17d Manna	Rottame	n.d.	n.d.	n.d.	n.d.	1.33	2.01 ± 0.2	5.33 ± 0.6	n.d.	
32-18c Manna	Rottame	n.d.	n.d.	4.11 ± 0.1	n.d.	1.40	3.31 ± 0.5	n.d.	n.d.	
33-9 Manna	Liquid	4.20 ± 0.5	n.d.	3.30 ± 0.3	n.d.	n.d.	2.33 ± 0.4	5.85 ± 0.4	3.80 ± 0.3	
34-9g Manna	Liquid	4.52 ± 0.2	n.d.	2.93 ± 0.4	n.d.	n.d.	4.97 ± 0.3	5.76 ± 0.1	2.97 ± 0.1	
35-9-1b Manna	Liquid	4.87 ± 0.3	n.d.	3.21 ± 0.1	n.d.	n.d.	5.25 ± 0.2	5.04 ± 0.3	3.22 ± 0.4	

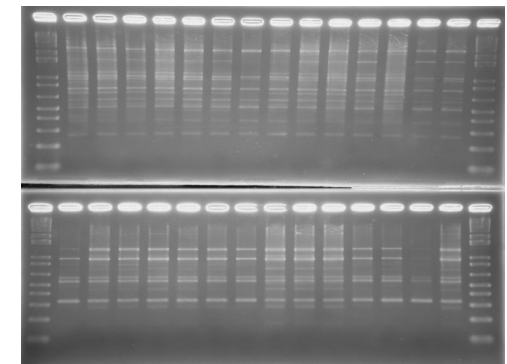
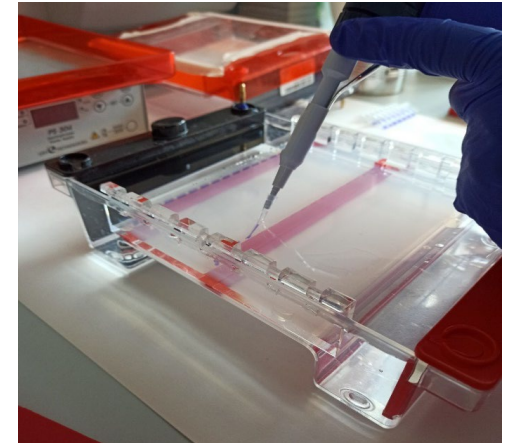
**Yeasts Osmo-Tolerant
1.7-5.8 CFU/g**



Yeasts Isolated from Manna and Honey



- *Saccharomyces cerevisiae*
- *Lachancea thermotolerans*
- *Citeromyces matritensis*
- *Candida aaseri*
- *Starmerella lactis-condensi*
- *Zygosaccharomyces bailii*
- *Zygosaccharomyces bisporus*
- *Meyerozyma guilliermondii*
- *Starmerella magnoliae*
- *Candida oleophila*
- *Hanseniaspora uvarum*



Preliminary screening: resistance to ethanol, hydrogen sulphide, hops, consumption of major sugars of beer wort and production of metabolites such as acids

From Honey and his by-products...



**Cooked, pressed,
fermented and
distilled**



**...to Spiritu
re Fascitrari**

The quest for new niches

Food Microbiology 38 (2014) 284–294



Contents lists available at ScienceDirect

Food Microbiology

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



Cultivable microorganisms associated with honeys of different geographical and botanical origin

Milko Sinacori, Nicola Francesca, Antonio Alfonzo, Margherita Cruciata, Ciro Sannino, Luca Settanni, Giancarlo Moschetti*



International Journal of Food Microbiology 261 (2017) 62–72



Contents lists available at ScienceDirect

International Journal of Food Microbiology

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



Production of the Sicilian distillate “Spiritu re fascitrari” from honey by-products: An interesting source of yeast diversity

Raimondo Gaglio*, Antonio Alfonzo, Nicola Francesca, Onofrio Corona, Rosalia Di Gerlando, Pietro Columba, Giancarlo Moschetti



The application of unconventional yeasts



Use of sequentially inoculation of *Saccharomyces cerevisiae* and *Hanseniaspora uvarum* strains isolated from honey by-products to improve and stabilize the quality of mead produced in Sicily

Rosario Prestianni^a, Michele Matraxia^a, Vincenzo Naselli^a, Antonino Pirrone^a, Natale Badalamenti^b, Marzia Ingrassia^a, Raimondo Gaglio^a, Luca Settanni^a, Pietro Columba^a, Antonella Maggio^b, Maurizio Bruno^b, Nicola Francesca^{a,*}, Giancarlo Moschetti^a, Antonio Alfonzo^a



Technological screening and application of *Saccharomyces cerevisiae* strains isolated from fermented honey by-products for the sensory improvement of *Spiritu re fascitrari*, a typical Sicilian distilled beverage

Nicola Francesca^a, Raimondo Gaglio^a, Michele Matraxia^a, Vincenzo Naselli^a, Rosario Prestianni^a, Luca Settanni^a, Natale Badalamenti^b, Pietro Columba^a, Maurizio Bruno^b, Antonella Maggio^{b,*}, Antonio Alfonzo^{a,**}, Giancarlo Moschetti^a



Continuos research and application

Food Research International 199 (2025) 115328



Contents lists available at ScienceDirect

Food Research International

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



Exploring the diversity of native *Lachancea thermotolerans* strains isolated by sugary extracts from manna ash to modulate the flavour of sour beers

Antonino Pirrone^a, Vincenzo Naselli^a, Rosario Prestianni^a, Ignazio Maria Gugino^a, Enrico Viola^a, Filippo Amato^a, Antonella Porrello^b, Aldo Todaro^a, Antonella Maggio^b, Maurizio Bruno^b, Luca Settanni^a, Carmelo Radici^c, Raffaele Guzzon^d, Rosario Schicchi^a, Giancarlo Moschetti^a, Nicola Francesca^{a,*}, Antonio Alfonzo^a

Food Research International 208 (2025) 116164



Contents lists available at ScienceDirect

Food Research International

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



Use of non-conventional yeasts for enhancing the sensory quality of craft beer

Antonino Pirrone^a, Vincenzo Naselli^a, Ignazio Maria Gugino^a, Antonella Porrello^b, Enrico Viola^a, Valentina Craparo^a, Azzurra Vella^a, Davide Alongi^a, Venera Seminerio^a, Micaela Carusi^a, Carmelo Radici^c, Filippo Amato^a, Raffaele Guzzon^d, Aldo Todaro^e, Raimondo Gaglio^a, Luca Settanni^a, Antonella Maggio^b, Giancarlo Moschetti^a, Nicola Francesca^{a,*}, Antonio Alfonzo^a



Improving aroma characteristics

International Journal of Food Microbiology 360 (2021) 109325



Contents lists available at [ScienceDirect](https://www.sciencedirect.com)

International Journal of Food Microbiology

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



Effects of different yeast strains, nutrients and glutathione-rich inactivated yeast addition on the aroma characteristics of Catarratto wines

Antonio Alfonso^a, Rosario Prestianni^a, Raimondo Gaglio^a, Michele Matraxia^a, Antonella Maggio^b, Vincenzo Naselli^a, Valentina Craparo^a, Natale Badalamenti^b, Maurizio Bruno^b, Paola Vagnoli^c, Luca Settanni^a, Giancarlo Moschetti^a, Nicola Francesca^{a,*}



antioxidants



Article

Improving the Aromatic Profiles of Catarratto Wines: Impact of Metschnikowia pulcherrima and Glutathione-Rich Inactivated Yeasts

Vincenzo Naselli¹, Rosario Prestianni¹, Natale Badalamenti², Michele Matraxia¹, Antonella Maggio^{2,*}, Antonio Alfonso^{1,*}, Raimondo Gaglio¹, Paola Vagnoli³, Luca Settanni¹, Maurizio Bruno², Giancarlo Moschetti¹ and Nicola Francesca¹



Experimental plan - Assays in synthetic beer wort

Influence of non-conventional yeasts on the aromatic composition of *Eriobotrya japonica* Lindl beer

International Journal of Food Microbiology 379 (2022) 109868

Contents lists available at ScienceDirect

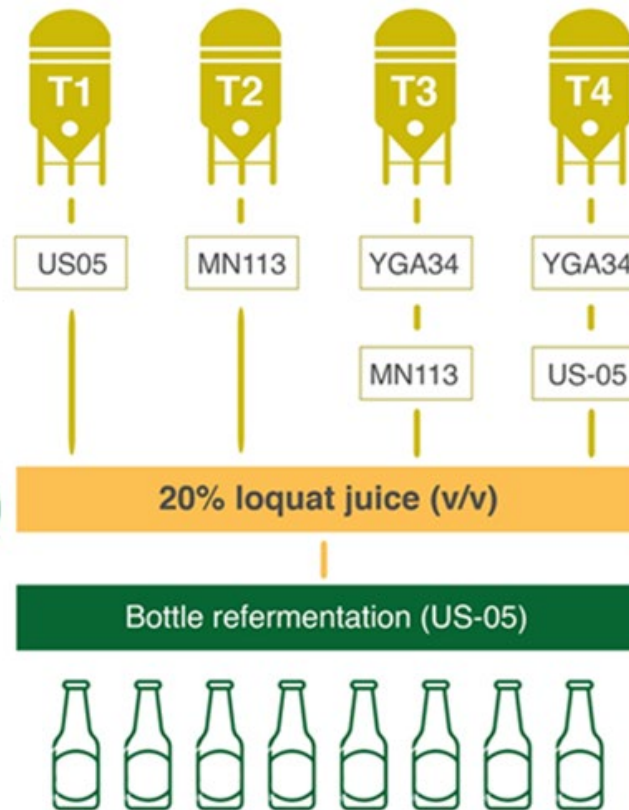
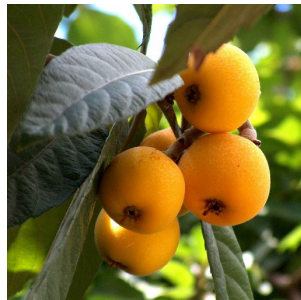
International Journal of Food Microbiology

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

Influence of indigenous *Hanseniaspora uvarum* and *Saccharomyces cerevisiae* from sugar-rich substrates on the aromatic composition of loquat beer

Antonino Pirrone^a, Rosario Prestianni^a, Vincenzo Naselli^a, Aldo Todaro^a, Vittorio Farina^a, Ilenia Tinebra^a, Guzzon Raffaele^b, Natale Badalamenti^c, Antonella Maggio^c, Raimondo Gaglio^a, Luca Settanni^a, Maurizio Bruno^c, Giancarlo Moschetti^a, Antonio Alfonso^{a,*}, Nicola Francesca^a

^a Department of Agricultural, Food and Forest Sciences, University of Palermo, Viale delle Scienze Bldg. 5, Ent. C., 90128 Palermo, Italy
^b Fondazione Edmund Mach, Via Mach 1, 38010 San Michele all'Adige, TN, Italy
^c Department of Biological, Chemical and Pharmaceutical Sciences and Technologies (STEBICEP), University of Palermo, Viale delle Scienze, Parco d'Orleans II, Palermo, building 17, Italy



Legend

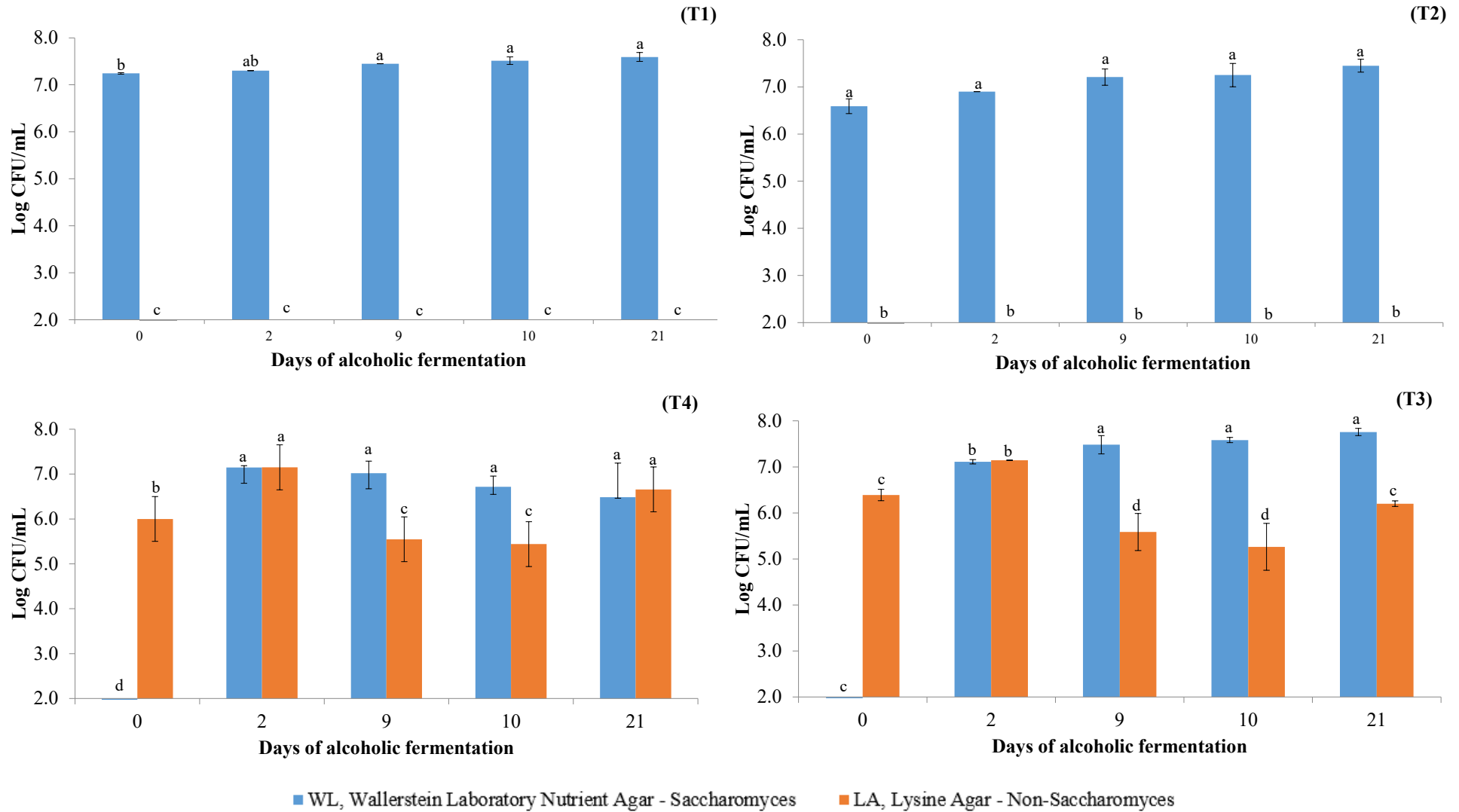
US-05 Commercial yeast strain

MN113 Yeast strain from Manna ash

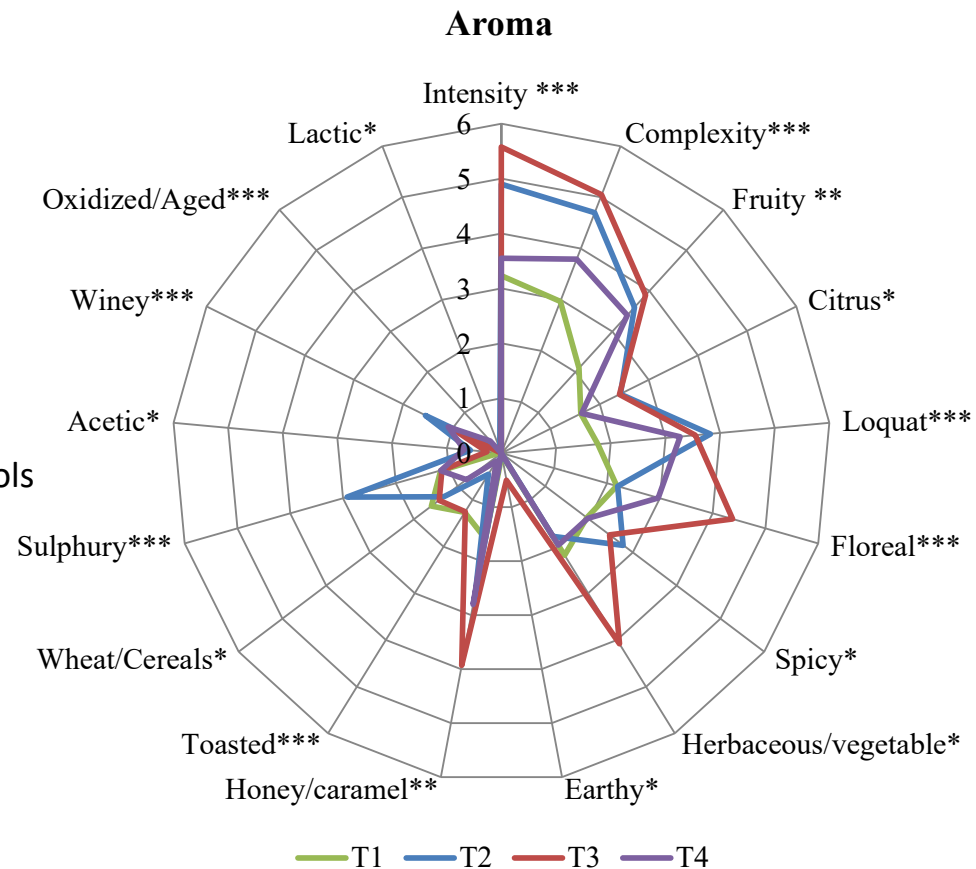
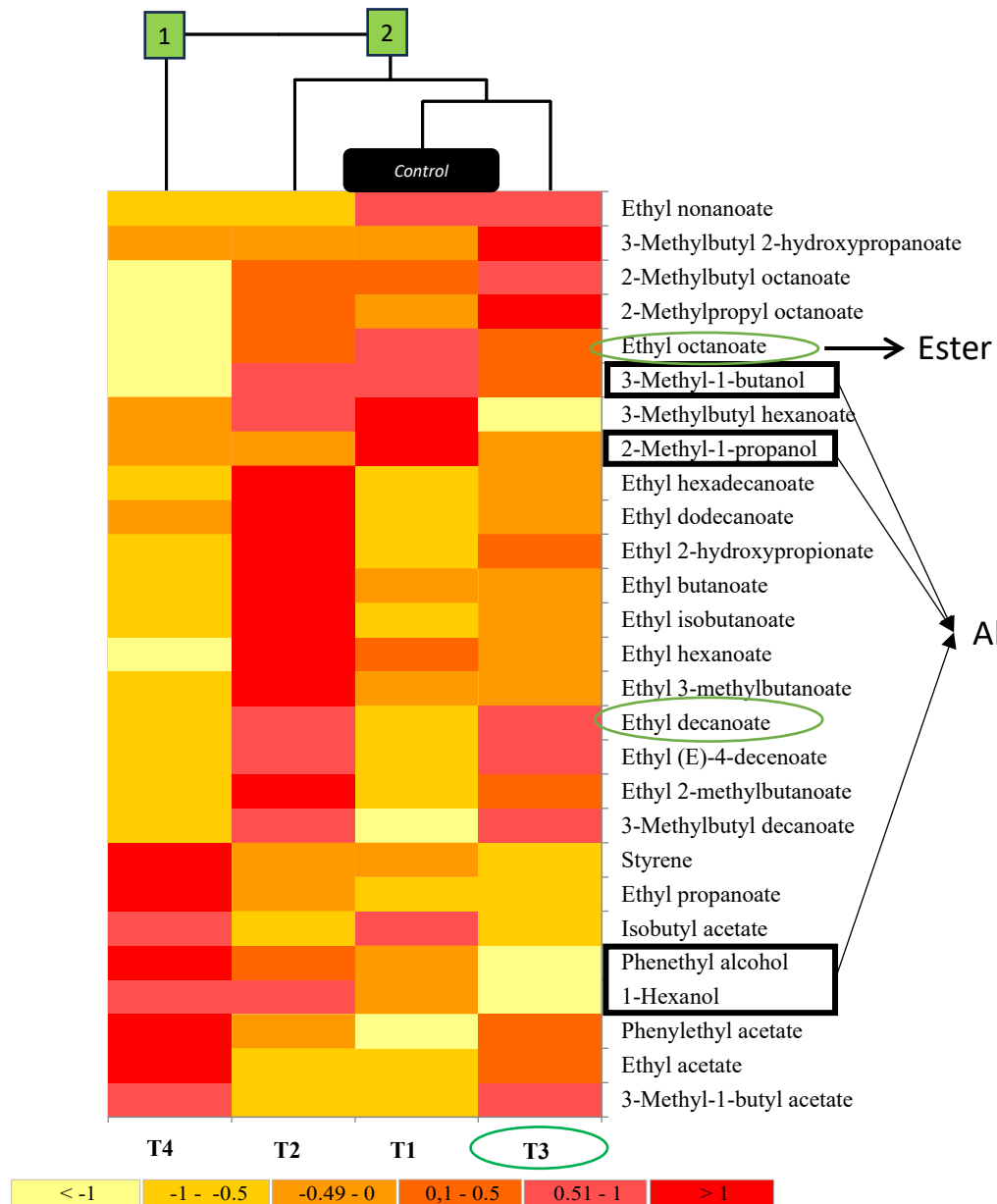
YGA34 Yeast strain from Honey by products

US05: *Saccharomyces cerevisiae*
 MN113: *Saccharomyces cerevisiae*
 YGA34: *Hanseniaspora uvarum*

Microbiological results

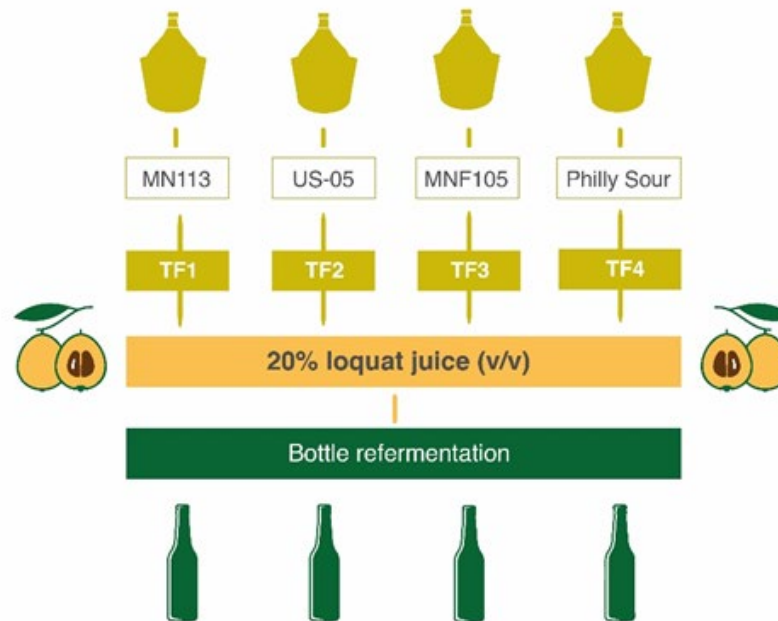
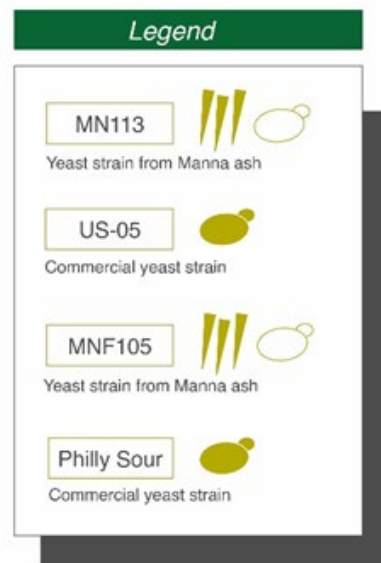


Voc's and sensory analysis results



Experimental plan - Loquat Beer production

A novel microbiological approach to impact the aromatic composition of sour loquat beer



Food Bioscience 55 (2023) 103011

Contents lists available at ScienceDirect

Food Bioscience

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

A novel microbiological approach to impact the aromatic composition of sour loquat beer

Nicola Francesca^a, Antonino Pirrone^a, Ignazio Gugino^a, Rosario Prestianni^a, Vincenzo Naselli^a, Luca Settanni^a, Aldo Todaro^a, Raffaele Guzzon^b, Antonella Maggio^c, Antonella Porrello^c, Maurizio Bruno^c, Vittorio Farina^a, Roberta Passafiume^a, Antonio Alfonso^{a,d}, Giancarlo Moschetti^a, Raimondo Gaglio^a

^a Department of Agricultural, Food and Forest Sciences (SAAF), University of Palermo, Viale delle Scienze Bldg. 5, Ent. C, 90128, Palermo, Italy
^b Fondazione Edmund Mach, Via Mach 1, 37100, San Michele all'Adige, 38010, Italy
^c Department of Biological, Chemical and Pharmaceutical Sciences and Technologies (STERBECEP), University of Palermo, Viale delle Scienze, Parco d'Orleans II, Palermo, Bldg. 17, Italy

- MN113:** *Saccharomyces cerevisiae*
- US05:** *Saccharomyces cerevisiae*
- MNF105:** *Lachancea thermotolerans*
- Philly sour:** *Lachancea thermotolerans*



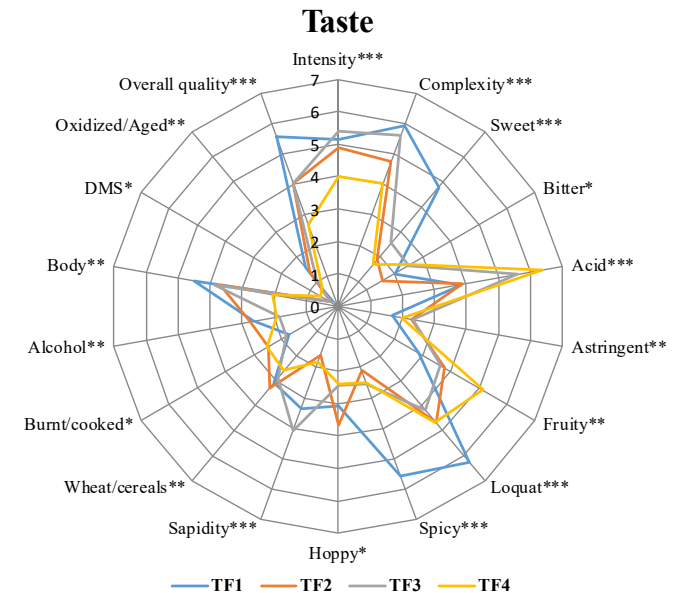
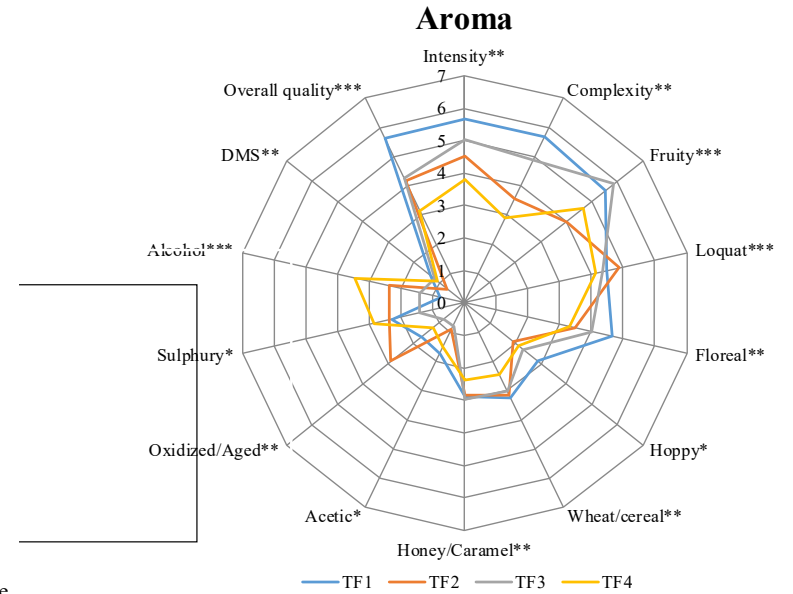
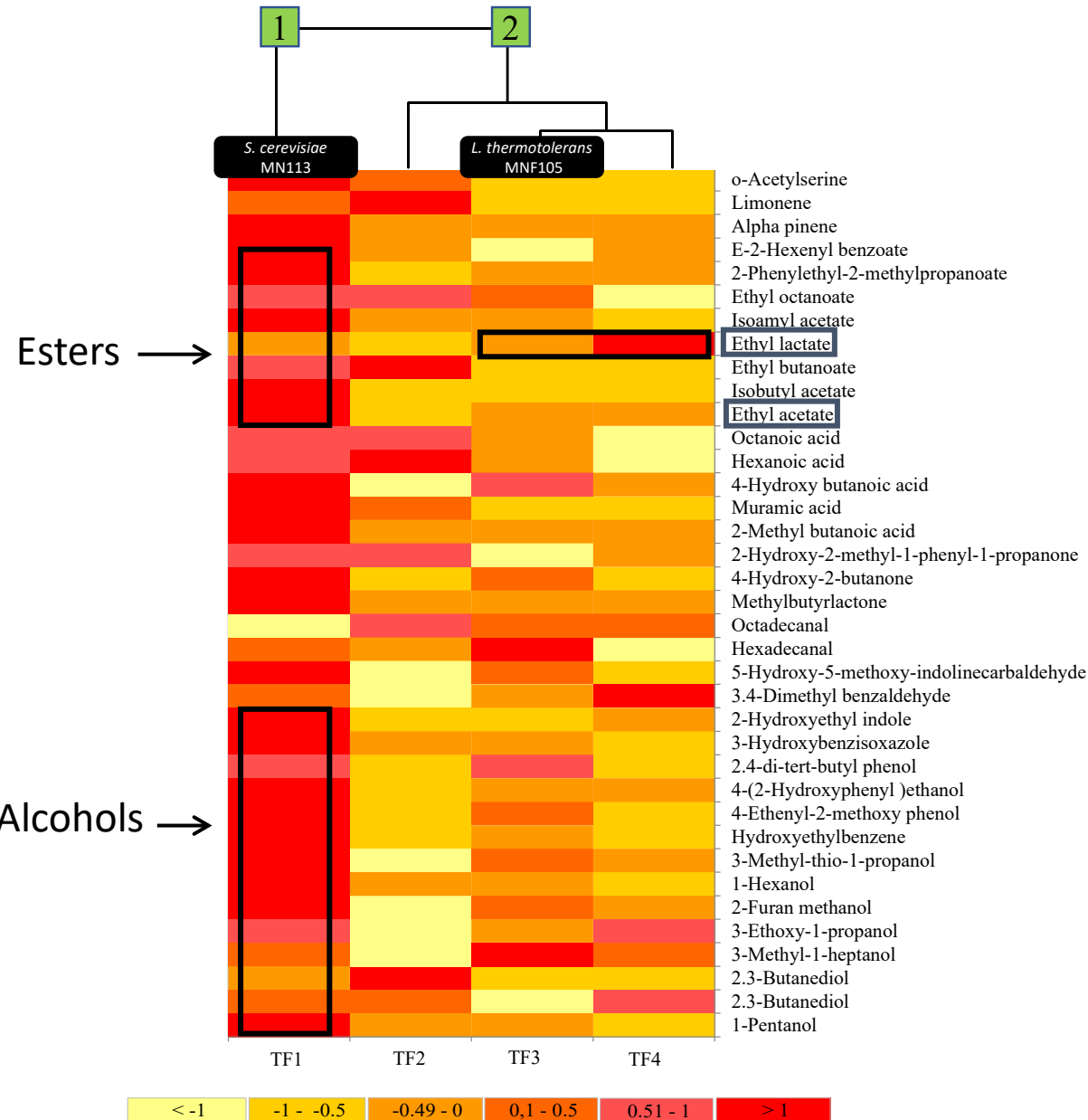
Results of conventional chemical parameters

	TF1	TF2	TF3	TF4	S.S.
D-fructose (g/L)	0.01 ± 0.00 ^b	0.01 ± 0.00 ^b	0.02 ± 0.01 ^{ab}	0.04 ± 0.01 ^a	**
D-glucose (g/L)	0.03 ± 0.00 ^b	0.04 ± 0.01 ^b	0.05 ± 0.05 ^a	0.04 ± 0.02 ^b	**
Maltose (g/L)	5.42 ± 0.22 ^a	0.45 ± 0.05 ^b	5.82 ± 0.61 ^a	5.53 ± 0.83 ^a	***
D-sucrose (g/L)	0.16 ± 0.05 ^a	0.07 ± 0.02 ^a	0.18 ± 0.09 ^a	0.13 ± 0.08 ^a	N.S.
Lactic acid (g/L)	0.04 ± 0.02 ^b	0.05 ± 0.02 ^b	0.49 ± 0.08 ^b	1.74 ± 0.36 ^a	***
Acetic acid (g/L)	0.14 ± 0.02 ^a	0.03 ± 0.01 ^b	0.09 ± 0.02 ^{ab}	0.13 ± 0.05 ^a	N.S.
L-Malic Acid (g/L)	1.56 ± 0.12 ^a	1.81 ± 0.11 ^a	1.83 ± 0.15 ^a	1.80 ± 0.21 ^a	N.S.
Glycerol (g/L)	3.32 ± 0.22 ^a	3.17 ± 0.09 ^a	3.54 ± 0.16 ^a	3.51 ± 0.21 ^a	N.S.
Tartaric acid (g/L)	0.32 ± 0.04 ^a	0.38 ± 0.09 ^a	0.38 ± 0.08 ^a	0.34 ± 0.08 ^a	N.S.

	TF1	TF2	TF3	TF4	S.S.
Alcohol (% vol)	4.35 ± 0.12 ^b	5.04 ± 0.11 ^a	4.28 ± 0.15 ^b	4.21 ± 0.21 ^b	***
Density (FG)	1012.6 ± 1.1 ^a	1007.4 ± 1.2 ^b	1013.4 ± 0.8 ^a	1013.2 ± 0.5 ^a	***
Real extract (°P)	5.19 ± 0.12 ^a	4.13 ± 0.13 ^b	5.33 ± 0.08 ^a	5.28 ± 0.07 ^a	***
Energy (kcal/100g)	44 ± 0.12 ^a	43 ± 0.13 ^a	44 ± 0.08 ^a	43 ± 0.08 ^a	N.S.
Apparent extract (°P)	3.69 ± 0.12 ^a	2.35 ± 0.12 ^b	3.87 ± 0.12 ^a	3.83 ± 0.12 ^a	***
Original extract (°P)	11.78 ± 0.08 ^a	11.8 ± 0.06 ^b	11.8 ± 0.10 ^a	11.65 ± 0.08 ^a	***
Specific gravity (°P)	1014.5 ± 1.10 ^a	1009.2 ± 0.90 ^b	1015.2 ± 1.20 ^a	1015 ± 1.23 ^a	***
Real attenuation (%)	57.5 ± 1.15 ^b	66.4 ± 1.82 ^a	56.4 ± 1.35 ^b	56.2 ± 1.38 ^b	***
pH	3.80 ± 0.10 ^a	3.81 ± 0.08 ^a	3.65 ± 0.12 ^{ab}	3.49 ± 0.06 ^b	*

Beer fermented by: *S. cerevisiae* MN113 (TF1); *S. cerevisiae* US05 (TF2); *L. thermotolerans* MNF105 (TF3); *L. thermotolerans* PHILLY SOUR (TF4). Data in the same line followed by the same letter are not significantly different according to Tukey's test. Symbols: ***, P < 0.001; **, P < 0.01; * P < 0.05; N.S., not significant.

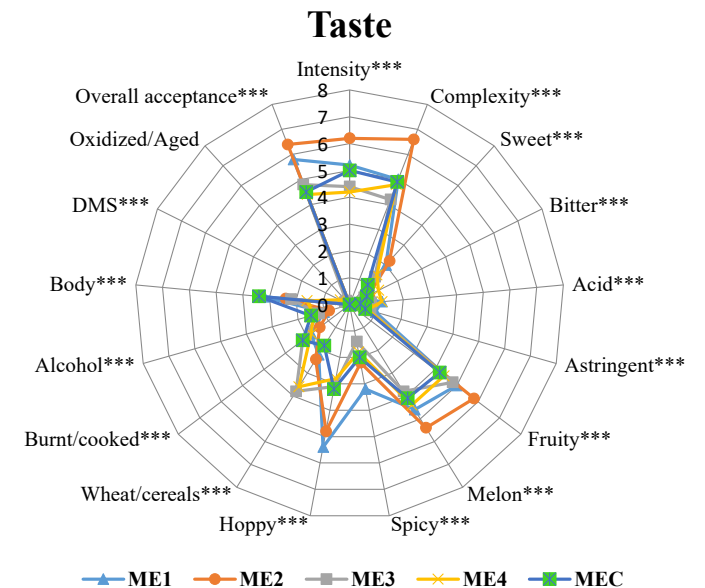
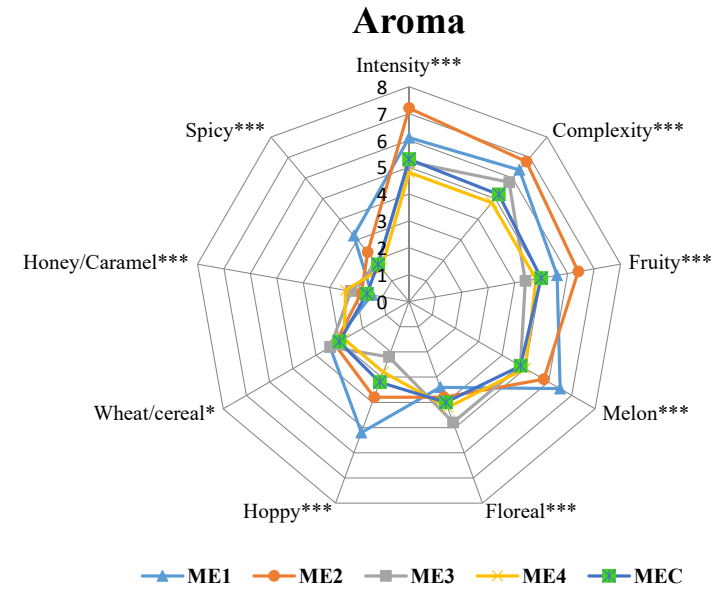
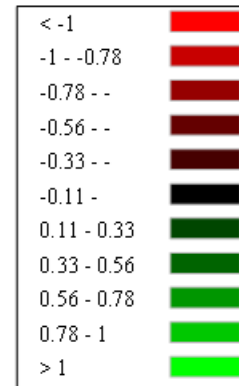
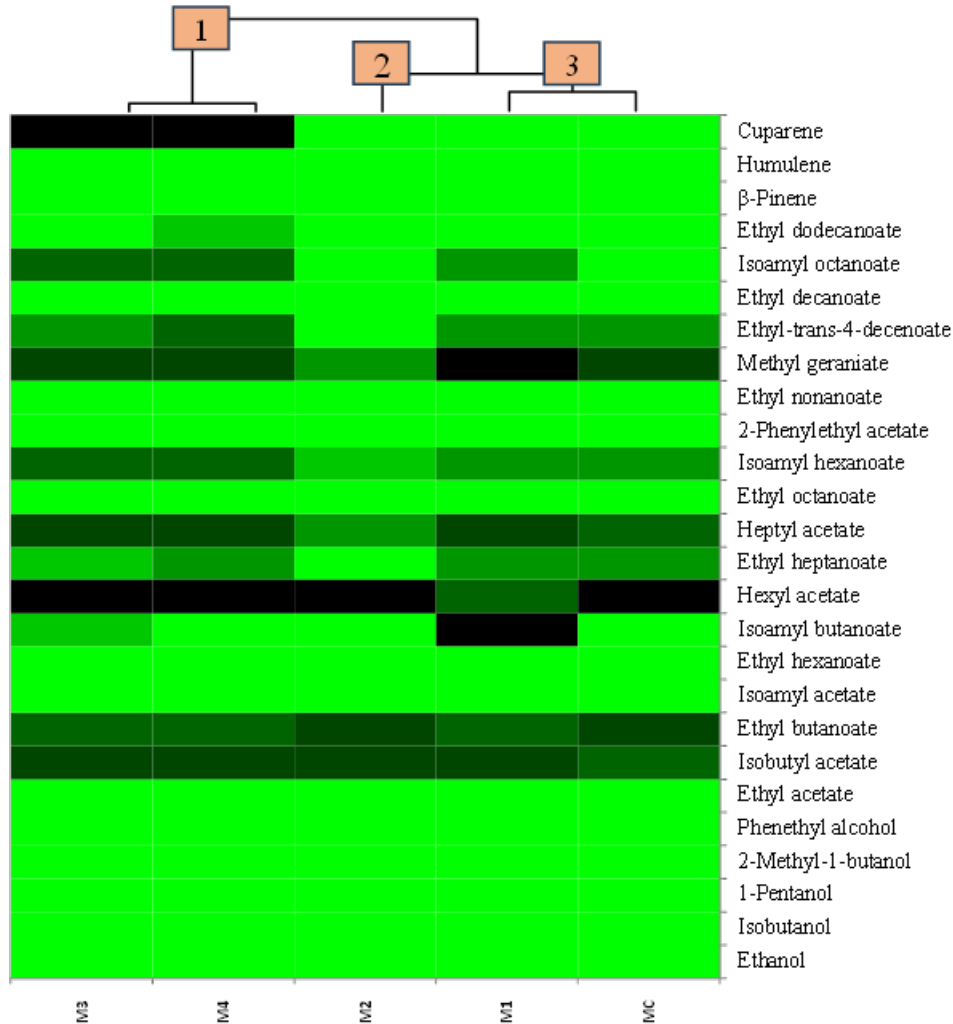
Voc's and sensory analysis results



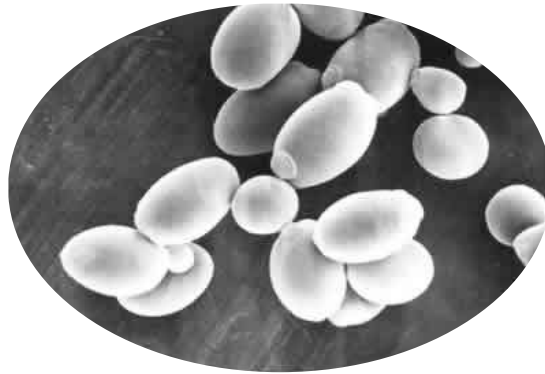
Experimental plan - Melon Beer production



Voc's and sensory analysis results



Ongoing studies.....



Multi-functional and low-alcohol beverages



Industrial scale application



Technology transfer trials are in progress at the commercial brewery Epica srl (Sinagra, Messina)

Yeast strains under investigation: *Hanseniaspora uvarum* YGA34, *Lachancea thermotolerans* MNF105, *Candida oleophila* YS209 and *Saccharomyces cerevisiae* MN113.



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This research was partly financed by the research project of the Sicilian Region for the support of inland areas (LIVING LAB NEBRODI)



Postharvest Management of Mediterranean Crops

9° Workshop GDL SOI Postraccolta

Funded projects on the topic

PhD scholarship funded by Piano Stralcio «Ricerca e innovazione 2015-2017» – Asse “Capitale Umano”, del Fondo per lo Sviluppo e la Coesione (FSC)

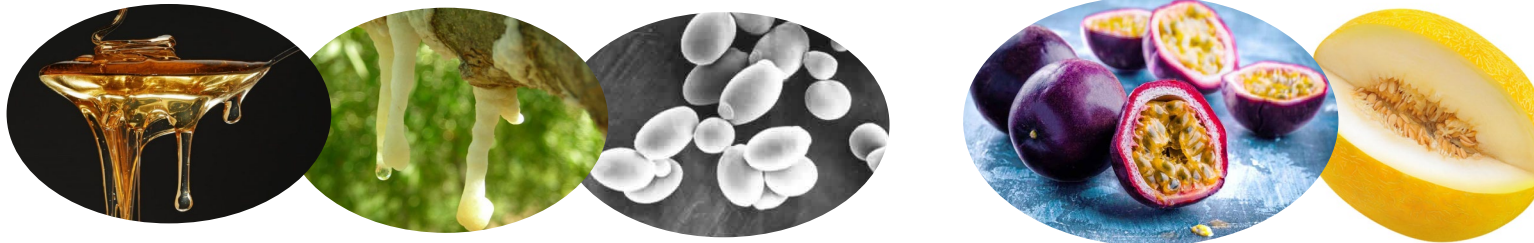


Research project named “SNC (Sinagra, Sicily, Italy). Beer & Bioflavouring: nuove strategie per l’aumento della complessità aromatica della birra artigianale di Sicilia”, prot. N. 4413-20/06/2022 with Birra Epica



Sicani Living Lab

Conclusion



- High microbial diversity in manna and honey;
- Strains with excellent fermentation characteristics;
- These strains have been shown to be able:
 - to conduct beer fermentation,
 - to produce a good amount of desirable volatile organic compounds,
 - to produce flavors to enhance the aromatic complexity of fruit beers.

These innovative beverages are particularly appreciated by consumers

Thanks for your attention

Nicola Francesca

Department of Agricultural, Food and Forest Sciences
University of Palermo - Italy



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The role of non-*Saccharomyces* in beer

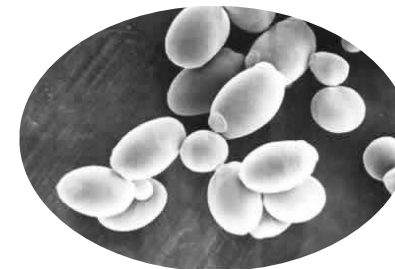
Beer is an alcoholic fermentend beverage produced through the alcoholic fermentation of beer wort (water, malt and hops).

The most commonly used yeasts are different strains of:

- *Saccharomyces cerevisiae*: top-fermenting beers
- *Saccharomyces pastorianus*: bottom-fermenting beers

Non-*Saccharomyces* yeasts also referred to as "non-conventional yeasts" are all those yeasts not belonging to the *Saccharomyces* genus

- These yeast species have often been viewed negatively due to potential problems with beer safety, turbidity, filterability, off-flavours, acidity and altered flavour profiles;
- However, if properly selected and used, non-*Saccharomyces* yeasts can confer favourable properties;
- Extensive research has revealed their significant role in shaping beer aroma and improving sensory characteristics, which prompts the study of the use of non-*Saccharomyces* strains in brewing.



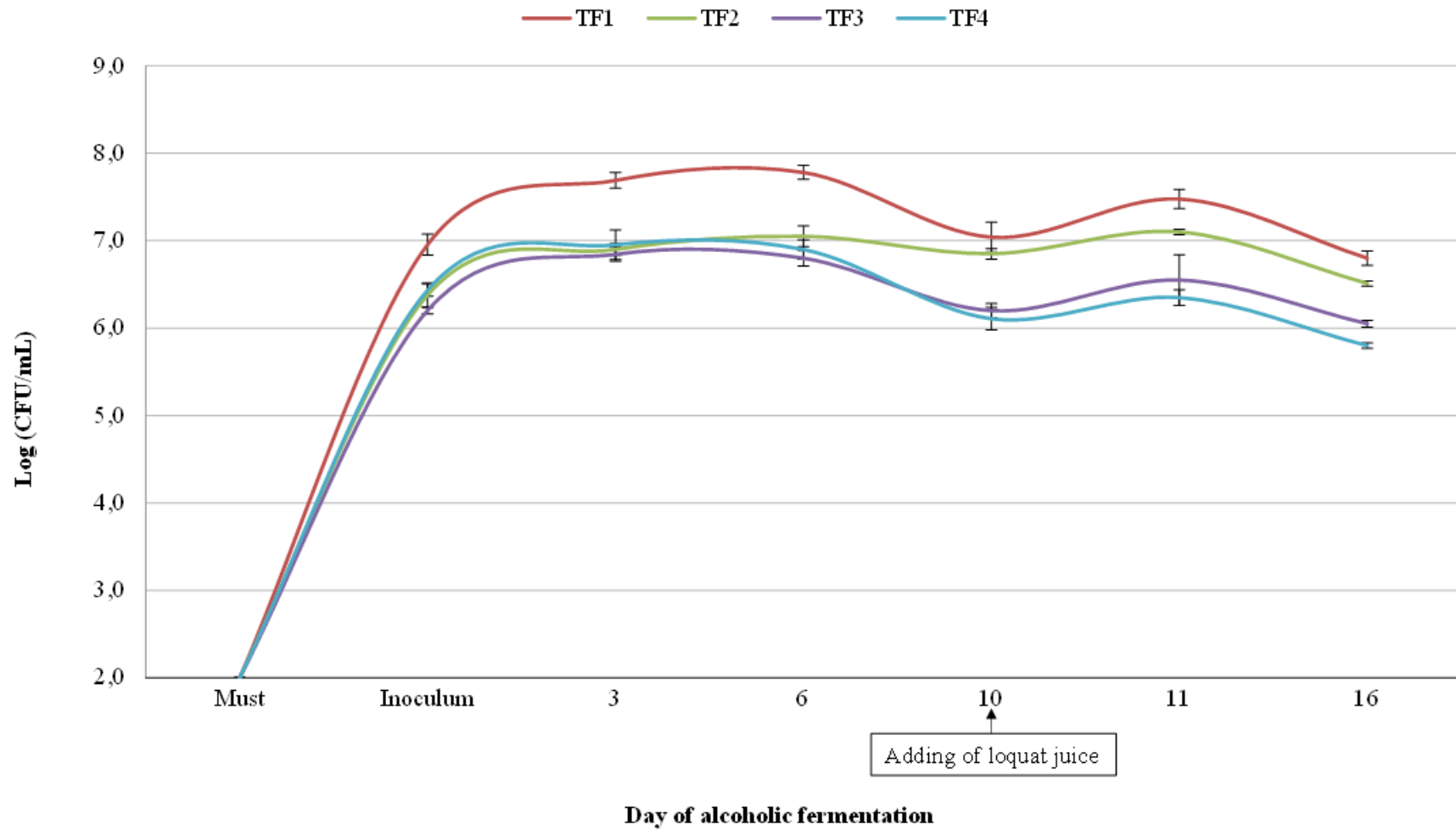
Results of conventional chemical parameters

	Wort
D-fructose (g/L)	2.00 ± 0.20
D-glucose (g/L)	39.63 ± 0.28
Maltose (g/L)	20.77 ± 0.05
D-sucrose (g/L)	24 ± 0.21
Acetic acid (g/L)	0.04 ± 0.08
L-Malic Acid (g/L)	0.20 ± 0.01
Glycerol (g/L)	0.06 ± 0.01
Tartaric acid (g/L)	0.09 ± 0.01

	T1	T2	T3	T4	S.S.
D-fructose (g/L)					
2d	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	N.S.
9d	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	N.S.
10d (+Fr)	6.18 ± 1.22 ^a	6.18 ± 1.22 ^a	6.18 ± 1.22 ^a	6.18 ± 1.22 ^a	N.S.
End AF	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	N.S.
D-glucose (g/L)					
2d	8.49 ± 0.77 ^a	0.35 ± 0.25 ^b	14.03 ± 2.91 ^a	13.94 ± 2.75 ^a	**
9d	3.66 ± 0.04 ^a	0.28 ± 0.27 ^b	3.65 ± 0.06 ^a	3.65 ± 0.09 ^a	***
10d (+Fr)	5.65 ± 0.43 ^a	2.03 ± 1.77 ^b	3.08 ± 0.80 ^a	5.29 ± 0.29 ^a	*
End AF	0.06 ± 0.01 ^a	0.04 ± 0.03 ^a	0.04 ± 0.04 ^a	0.03 ± 0.01 ^a	N.S.
Maltose (g/L)					
2d	15.55 ± 0.54 ^a	11.47 ± 1.25 ^b	18.98 ± 1.36 ^a	18.85 ± 1.81 ^a	***
9d	7.14 ± 0.92 ^b	3.33 ± 0.15 ^c	2.55 ± 0.18 ^c	14.21 ± 1.41 ^a	***
10d (+Fr)	4.87 ± 0.29 ^b	1.64 ± 0.14 ^c	2.6 ± 0.19 ^c	9.75 ± 0.54 ^a	***
End AF	0.37 ± 0.09 ^b	1.98 ± 0.23 ^a	1.90 ± 0.21 ^a	0.94 ± 0.24 ^b	***
D-sucrose (g/L)					
2d	6.18 ± 0.45 ^c	0.61 ± 0.08 ^d	13.88 ± 1.25 ^b	16.60 ± 1.05 ^a	***
9d	0.36 ± 0.06 ^a	0.38 ± 0.10 ^a	0.36 ± 0.05 ^a	0.39 ± 0.15 ^a	N.S.
10d (+Fr)	3.88 ± 0.13 ^a	1.06 ± 0.15 ^c	2.96 ± 0.05 ^b	4.32 ± 0.24 ^a	***
End AF	0.37 ± 0.04 ^b	0.34 ± 0.09 ^b	0.36 ± 0.13 ^b	0.36 ± 0.04 ^b	N.S.

Beer fermented by: US-05 (T1), MN113 (T2), sequential inoculum with YGA34 and MN113 (T3), sequential inoculum with YGA34 and US-05 (T4).

Microbiological results



Conclusion



- This project and its results can be a growth opportunity for the disadvantaged areas of Sicily, where cereals, fruit and water of excellent quality are produced
- Further investigations are underway to make these beverages on an industrial level
- Technology transfer trials are in progress at the commercial brewery Epica srl (Sinagra, Messina)
- This research was partially financed by the research project of the Region of Sicily for the support of inland areas (LIVING LAB)

SOUR FRUITS

ONLY FOODS



Bilberry



Cloudberry



Cranberry



Currant



Goji Berry



Gooseberry



Grapefruit



Soursop



Huckleberry



Lime



Kiwi



Kumquat



Star Fruit



Guava



Loganberry



Quince



Lemon



Tangelo



Thimbleberry



Acerola



Pomelo



Tamarind



Passion Fruit

