Maltose Negative Yeast in Non-Alcoholic and Low-Alcoholic Beer Production

Supplementary Files

Table S1. Comparison of sugar consumption, POF production and flocculation of selected yeast species.

Species	Maltose	Maltotriose	Glucose	Fructose	Sucrose	Raffinose	POF	Flocculation (%)	References
Saccharomycodes ludwigi	-	-	+	+	+	+	-	27.1 - 60	*
Saccharomyces cerevisiae **ERS1,**	-	-	+	+	+	+	+	18.5	[87]
EYS4								14.9	
Mrakia gelida	-	-	+	+	+	U	U	U	[36]
Trigonopsis cantarellii **P-69**	-	-	U	+	U	U	U	U	[92]****
Candida sojae **T-39**	-	-	U	+	U	U	U	U	[92]****
Candida shehatae	V	U	+	U	+	V	U	U	[97-99]
Candida zemplinina	-	U	U	U	U	U	U	U	[100,101]
Wickerhamomyces anomalus **P-2.4**	W	+	U	+	U	U	U	U	[92]****
Kazachstania servazzi **VTT C-191027**	-	U	U	U	U	U	U	4	[6]
Pichia fermentans **VTT C-191032**	-	U	U	U	U	U	U	0	[6]
Pichia kluvyeri **CBS 188**	-	U	+	U	-	-	U	U	[99]
Pichia kudriavzevii	V***	-	+	U	U	U	U	U	[102]
Cyberlindnera subsufficiens strain C6.1	_	U	+	U	+	+	-	32 ± 1	[5]
CBS 5763 **								51 ± 4	
Cyberlindnera misumaiensis 837 A	-	U	+	U	-	-	-	78 ± 3	[5]
Hanseniaspora valbyensis **KBI 22.1**	-	-	+	+	+	-	-	11 ± 8	[10]
Hanseniaspora vineae **KBI 7.1**	-	-	+	+	-	-	-	41 ± 4	[10]
Torulaspora delbrueckii **EGT1**	-	-	+	+	+	+	-	96.2	[87]
KBI 22.2								17 ± 0	[10]
Zygosaccharomyces bailii **KBI 25.2**	-	-	+	+	+	-	-	45 ± 0	[10]
Zygosaccharomyces kombuchaensis **KBI 5.4**	-	-	+	+	-	+	-	44 ± 3	[10]
Zygosaccharomyces rouxii DVBPG 4084 DVBPG 6187 DVBPG 6424 DVBPG 6463	+/W	U	+	V	-	U	U	U	[89]

DVBPG 6921									
***Zygosaccharomyces rouxi* CBS 732**	W	U	+	U	V	U	U	U	[99]
***Brettanomyces bruxellensis* BC02** **BC07** **BC11**	-	U	+	U	-	-	+	U	[103]
Brettanomyces bruxellensis	V	U	+	U	+	V	+	U	[99,104]

U- Undeclared; +/W, positive or weak; V, variable; POF, phenolic off-flavour, ± indicates the standard deviation.

*All *S. ludwigi* data were compatible among the references, for an easier evaluation all data combined: Maltose -[92] VTT-C181010, [89] DBVPG 3010, 3304, 3398, 3931, 4116, 6771, [10] TUM SL 17; WSL17 [36]; Maltotriose - [10]TUM SL 17, [36] WSL17; Glucose + [89]DBVPG 3010, 3304, 3398, 3931, 4116, 6771; [10] TUM SL 17, [36] WSL17; Fructose + [10]TUM SL 17, WSL17 [36]; Sucrose + [89] DBVPG 3010, 3304, 3398, 3931, 4116, 6771, [10] TUM SL 17, WSL17 [36]; Raffinose + [89] DBVPG 3010, 3304, 3398, 3931, 4116, 6771, [10] TUM SL 17, POF- [10] TUM SL 17: Flocculation% 27.1 [6] – 60± 7 [10] TUM SL 17.

**according to Kurtzman, et al. [104] growth on maltose "variable" [5].

*** consumption max 1 g/L

**** In Krogerus, et al. [92] yeast growth on various carbon sources (glucose, fructose, maltose and maltotriose) was measured in microplate cultivations and grouped into three groups: those capable of growing on both maltose and maltotriose, those only on maltose and those on neither. Shown as graphics. The blue areas were given here as negative. Yellow areas given here as weak usage (w) and orange and darker areas are given here positive.

Note: Even though their classification is controversial, species with limited maltose usage ability have also been added to this table due to their use in low alcohol beverages (The use of maltose for these varieties is very limited).

Table S2. Comparison of the suitability and aroma potential of selected maltose-negative yeast species.

Species	**Strain**	**Alcohol by volume**	**Trial Scale**	**Fermentation Parameters***	**pH**	**Volatile compounds evaluation**	**Sensory Notes**	**References**
Saccharomycodes ludwigi	C181010	0.43% ±0.00	2 L	5-10 °P, 25°C	4.84	High branched chain aldehydes noticed	"Worty" but also desirable fruity aromas were observed in fermented worts	[92]
	VTT C-181010	0.68%	10 L	8 °P, 25°C	4.78	Overproduction of 2-phenylethyl acetate than its flavour threshold	Predominantly, cereal, DMS, and Sweet taste descriptors were reported, but also malty and bready tastes were found. Body described as higher than in other samples. Apple notes were reported on the nose.	[6]
	TUM SL 17	0.50% ±0.01	2 L	6.6 °P, 25°C	5.67	0.80 / 21.05 (E/Ha mg/L)	Described as worty, honey, bread-like, or sweet	[10]
	WSL17	1.23% ±0.02	25 L	12 °P, 23 °C	4.60	9.35/42.23 (E/Ha mg/L)	Described as has yellow colour, a good clearance but with a weak foam head. Had apricot fruit with hop, cereal, malty and caramel notes.	[36]
	DBVPG 3010	0.51%	75 ml	12 kg/hl, 20 °C	U	14.91/43.31 (E/Ha mg/L) DBVPG 3010 had the highest diacetyl among the other *S. ludwigis* in the study 15.77 µg/L (still below the treshold) With its low ethanol production and appreciable ester-higher alcohol production. DBVPG 3010 identified to be a worthwhile yeast strain for NABLAB	U	[89]

						Production.		
	DBVP G3304	0.73%	75 ml	12 kg/hl, 20 °C	U	1.56/53.85 (E/Ha mg/L) Did not find proper due to low pleasant volatile compound production	U	[89]
	DBVP G 3398	0.72%	75 ml	12 kg/hl, 20 °C	U	1.21/47.66 (E/Ha mg/L) Did not find proper due to low pleasant volatile compound production	U	[89]
	DBVP G 3931	1.24 %	75 ml	12 kg/hl, 20 °C	U	2.35/62.34 (E/Ha mg/L) This strain produces a high amount of higher alcohols but also alcohol amount is higher than other *S. ludwigis*.	U	[89]
	DBVP G 4116	1.36 %	75 ml	12 kg/hl, 20 °C	U	4.15/76.62 (E/Ha mg/L) This strain produces high amount of higher alcohols but also alcohol production is higher than other *S. ludwigis*.	U	[89]
	DBVP G 3054	0.70%	75 ml	12 kg/hl, 20 °C	U	2.06/42.99 (E/Ha mg/L) Did not find proper due to low pleasant volatile compound production	U	[89]
	U	0.68 %		11.5 °P, 20 °C		1.82/45.30 (E/Ha mg/L) Diacetyl 140 (µg/L)	U	[110]
	CSIR-NCL 3261	1.2 % ±0.02	100 ml	12 °P, 16 °C	5.04	U	U	[109]
	U	0.47%		8.1 °P, 12 °C		1.9/39 (E/Ha mg/L) concentrations were found low	U	[97,105]
	DSM 3447	1.7 % ±0.06	200 ml	6.5 °P, 7 °C	3.47	U	U	[106]
	DSM 3447	0.15-1.20 %	U	6 °P, 4,12,24 °C	U	U	The treatments *with S. ludwigii* in 24 °C produced lactic acid and showed lactic sour attributes. In 4°C and 12°C had an undesirable sweet and immature flavour.	[112]
Saccharomyces cerevisiae	ERS1	1.28% ±0.01	1.5 L	15 P, 20 °C	4.60	ERS1's acetaldehyde amount was reported to be close to its flavour threshold. Ester production was reported higher in all Ecuadorian strains (ERS1, EYS4) compared to reference strains.	U	[87]
	EYS4	1.29% ±0.01	1.5 L	15 °P, 20 °C	4.58	Ester production was reported higher in all Ecuadorian strains (ERS1, EYS4) compared to reference strains.	U	[87]
Mrakia gelida	DBVP G 5952	1.16% ±0.11	25 L	12 °P, 10 °C	4.75	0.615/25.5 (E/Ha mg/L)	U	[36]

	Re-fermented DBVPG 5952	1.40% ±0.12	25 L	12 °P, 10 °C	4.71	3.516/27.7 (E/Ha mg/L)	Reported as having fruity with the apricot, grape and litchi descriptors but also with hop, cereal, malty and caramel notes. A better fruity olfactive intensity, compared to the beer made with *S. ludwigii.* In visual assessment the beer was defined as having poor head foam, yellow color and good clarity.	[36]
Trigonopsis cantarellii	P-69	0.14% ±0.00	2 L	5-10 °P, 25°C	4.81	Reported to contain high amounts of the desired monoterpene alcohol, trans-geraniol, and low amounts of aldehydes.	The lowest aldehyde levels (off-flavor) were reported in beer fermented with *T. cantarellii*. Also, it's performance found comparable to a commercial *S. ludwigii* reference strain.	[92]
Candida sojae	T-39	0.22% ±0.01	2 L	5-10 °P, 25°C	4.72	Reported to contain notably higher amounts of the trans-cis geraniol, which has a desirable rose note.	Notes of diacetyl were reported on the sensory panel in *C. sojae* beer. However, it's performance found comparable to a commercial *S. ludwigii* reference strain.	[92]
Candida shehatae	CICC 1766	0.47%	300 ml	9 °P, 14°C	U	Reported that the beer produced contains a high amount of ester and low amount of diacetyl (below 0.05 mg/L).	A similar flavour as a regular beer reported	[97,98]
	CICC 1766	0.37%	200 L	9 °P, 14°C	U	Containing a diacetyl of less than 0.05 mg/L	Reported that the produced non-alcoholic beer does not have the typical worty and sweet taste seen in non-alcoholic beers Produced with limited fermentation. Had a flavour similar to regular alcoholic beer	[97,98]
Candida zemplinina	Y.01667 Y.01670	1.5%	350 ml	12 °P, 18°C	4.8	U	In mixed fermentation trials with *S. cerevisiae* (in all fermentation media tested), *C. zemplinina* was reported as the most successful starter for non-alcoholic beer production with desired sensory properties	[100, 101]
Wickerhamomyces anomalus	P-2.4	0.60% ±0.00	2L	5-10 °P, 25°C	4.64	*W. anomalus* beer was reported as having the highest volatile ester concentrations	reported that *W. anomalus* beer was not liked because solvent-like tones were detected in smell and taste. It has been reported that this is due to ethyl acetate, produced at higher levels by *W. anomalus,* typically.	[92]
Kazachstania servazzi	VTT C-191027	0.73%	10 L	8 °P, 25°C	4.78	Production of 2-phenyl ethyl acetate at concentrations above the flavour threshold has been reported.	Reported that the descriptors of Cereal, DMS and Sweet were dominant in sensory analysis, but pear and apple notes were also detected. It has been noted that *K. servazzii* beer is characterized by a sweet aroma typical for low alcoholic beers.	[6]

Pichia fermentans	VTT C-191032	0.52%	10 L	8 °P, 25°C	4.79	A higher amount of 2-Phenylethanol production (2.77 mg/L) and lower amount of acetaldehyde (2.34 mg/L) than other studied yeast strains (*K. servazzii* and *S. Ludwigi*)	Stated that the beer had a cinnamon and clove-like spicy-phenolic flavour reminiscent of Belgian and German beers fermented by "POF+" yeasts. The taste has been described as original and pleasant. In addition to these, it has been reported that *P. fermentans* beer has lower DMS and cereal values than other samples, and contains notes of banana and melon.	[6]
Pichia kluvyeri	PK-KR1	0.1%	1000 L	8.3 P, 20°	U	25/20 (E/Ha)	Reported that its flavour is very close to a beer containing alcohol at least 4% (v/v). Sensory examination has reported higher amounts of desired esters such as phenylethyl acetate, and isoamyl acetate and lower amounts of undesired acids such as decanoic and octanoic acids in beer.	[97] [110]
Pichia kudriavzevii	Pk129	0.5-0.8 %		12 °P	U	50/50 (E/Ha mg/L) *P. kudriavzevii* found as producing relatively more desired volatiles in a balance	U	[102]
Cyberlindnera subsufficiens	C6.1	0.36% ±0.00	60 L	7 °P, 17°C	4.45	12.8/9.8 (E/Ha mg/L)	Described as pleasantly fruity (banana, pear, maracuja and mango) and has also been reported to have a bit worty-like character in sensory examination.	[5]
	CBS 5763	0.67% ±0.00	1 L	7 °P, 17°C	4.33	7.82/21.03 (E/Ha mg/L)	Described as Fruity, pleasant, but C6.1 strain found more pleasantly aromatic.	[5]
Cyberlindnera misumaiensis	837 A	0.55% ±0.01	1 L	7 °P, 17°C	4.41	67.26/22.80 (E/Ha mg/L)	Its beer found as solvent-like and unpleasant	[5]
Hanseniaspora valbyensis	KBI 22.1	0.35% ±0.01	2 L	6.6 °P, 25°C	4.84	0.9/23.3 (E/Ha mg/L) For isoamyl alcohol values was exhibiting highest (16.5 mg/L) in study. Unwanted diacetyl levels were above the flavor threshold in light beers.	Reported to have a "cereal-like" character and the diacetyl flavor was felt by half of the panelists.	[10]
Hanseniaspora vineae	KBI 7.1	0.34% ±0.02	2 L	6.6 °P, 25°C	4.78	6/20.2 (E/Ha mg/L)	Defined as sweet, must-like, honey-like, with black tea and caramel tones.	[10]
Torulaspora delbrueckii	EGT1	1.32% ±0.01	1.5 L	15 °P, 20 °C	4.65	High ester production. Had the best E:HA ratio in studied yeast strains (*S. cerevisiae* ERS1 and EYS4)	U	[87]

	VTT C-191036	0.8%–1.0%	2 L	8 °P, 25°C	4.60-4.75	*T. delbruecki* strains have been reported to be effective reductants with reducing branched chain aldehydes more than 90% compared to wort.	U	[6]
	KBI 22.2	0.5% ±0.01	2 L	6.6 °P, 25°C	4.69	0.77/18.1 (E/Ha mg/L) It was reported that non-alcoholic beer produced with *T. delbrueckii* KBI 22.2 contained the least amount of isoamyl alcohol (10.4 mg/L) among other samples in the study	Described as cereal-like honey-like, wort-like and bread-like by all panellist. Half of the panellist detected the unpleasant diacetyl flavour.	[10]
Zygosaccharomyces bailii	KBI 25.2	0.42% ±0.07	2 L	6.6 °P, 25°C	4.71	1/23.1 (E/Ha mg/L)	reported that it has the best potential among the yeasts studied in brewing non-alcoholic beer with its improved sensorial character	[10]
Zygosaccharomyces kombuchaensis	KBI 5.4	0.48% ±0.01	2 L	6.6 °P, 25°C	4.61	1/22 (E/Ha mg/L) Unwanted diacetyl levels were above the flavour threshold in light beers.	Described as honey-like, wort-like, bread-like. Unwanted diacetyl notes detected by the half of the panellists	[10]
Brettanomyces bruxellensis	LTQB 6	4%	1.2 L	16 °P, 28 °C	U	According to study, produced a higher acetaldehyde concentration than threshold value	U	[113]
Zygosaccharomyces rouxii	DVBPG 4084	1.63%	75 ml 12 kg/hl, 20 °C		U	Reported that *Z. rouxii* strains produced the highest amount of volatile compounds, especially higher alcohols as well as diacetyl and acetaldehyde. Because it produces ethanol at high levels (more than 1.2% v/v), it is therefore not suitable for low alcohol beer production.	U	[89]
	DVBPG 6921	1.46%						
	DVBPG 6424	2.74%						
	DVBPG 6463	3.32%						
	DVBPG 6187	0.93%	75 ml	12 kg/hl, 20 °C	U	33.78/92.07 (E/Ha mg/L) Reported that *Z. rouxii* strains produced the highest amount of volatile compounds, especially higher alcohols as well as diacetyl and acetaldehyde. DVBPG 6187 has the highest diacetyl with 851.40 (µg/L)	U	[89]

± indicates the standard deviation, U- Undeclared.
E/Ha indicates, Esters/ Higher alcohols ratio (mg/L)
*Wort concentration and fermentation temperature

Table S3. Comparison of selected volatile compounds in beers produced with some maltose-negative yeasts for NABLAB craft beer production (mg/L)

Compound	*S. ludwigii* VTT-C181010	*S. ludwigii TUM SL 17*	*S. ludwigii* WSL17	*S. ludwigii* DBVPG 3010	*T. cantarellii* P-69	*C. sojae* T-39	*Cyberlindnera subsuffi ciens* C6.1	*H. valbyensis* KBI 22.1	*H. vineae* KBI 7.1	*Z. bailii* KBI 25.2	*Mrakia gelida* DBVPG 5952
Acetaldehyde	4.9	8.5 ± 0.7	0.92 ±0.1	4.42	3.7	2.25	10.55	3.3 ± 0.4	4.1 ± 0.4 a	4.9 ± 1.3	2.30 ± 0.18
n-Propanol	2.35	2.6 ± 0.9	2.6 ± 0.0	3.25	3.4	1.95	2.20	2.1 ± 0.1 a	2.2 ± 0.0	0.56 ± 0.03	5.7 ± 0.4
Isobutanol	6.1	6.4 ± 0.1	13.03 ± 1.1	5.27	2.3	7.2	3.60	4.8 ± 0.1	4.6 ± 0.3	5.7 ± 0.1	9.8 ± 0.2
3-Methyl-1-butanol	U	U	14.3 ± 0.8	U	U	U	U	U	U	U	6.0 ± 0.3
3-Methyl-2-butanol	U	U	14.40	U	U	U	U	U	U	U	
2-Methyl-1-butanol	U	U	5.5 ± 0.2	4.48	U	U	U	U	U	U	1.4 ± 0.1
Furfuryl alcohol	U	U	U	1.44	U	U	U	U	U	U	
2-Phenylethanol (Phenyl alcohol)	8.1	U	6.8 ± 0.7	14.47	0.75	1.85	U	U	U	U	2.6 ± 0.1
Iso-amyl alcohol (3-methylbutanol)	14.65	12.1 ± 0.4	U	U	1.4	13.25	4.00	16.5 ± 1.1	13.4 ± 0.1	14.8 ± 0.2	U
Ethyl acetate	1.5	0.8± 0.01	9.3 ± 0.3	14.86	<0.59	<0.59	12.00	0.90 ± 0.05	6.00 ± 0.14	1.00 ± 0.00	0.6 ± 0.1
so-butyl acetate	<0.06	U	U	U	<0.06	<0.06	U	U	U	U	U
Iso-amyl acetate	<0.14	<0.1	0.03 ± 0.00	0.022	<0.14	<0.14	0.80	<0.1	<0.1	<0.1	ND
Phenyl ethyl acetate	<0.4	U	U	U	<0.4	<0.4	U	U	U	U	U
Ethyl hexanoate	<0.02	U	0.011 ± 0.002	0.014	<0.02	<0.02	U	U	U	U	0.009 ± 0.001
Ethyl octanoate	<0.4	U	0.009 ± 0.002	0.011	<0.4	<0.4	U	U	U	U	0.006 ± 0.001
Ethyl decanoate	<0.1	U	U	U	<0.1	<0.1	U	U	U	U	U
Ethyl dodecanoate	<0.1	U	U	U	<0.1	<0.1	U	U	U	U	U
Ethly formate	U	1.01± 0.13	U	U	U	U	U	0.78 ± 0.06	0.76 ± 0.03	0.56 ± 0.03	U
Furfural	U	U	0.01 ±0.0	U	U	U	U	U	U	U	0.007 ± 0.00
Methional	U	U	0.006 ± 0.3		U	U	U	U	U	U	0.009 ± 0.00
2-Methylbutanal	U	U	0.002 ± 0.0	0.079	U	U	U	U	U	U	0.001 ± 0.00

3-Methylbutanal	U	U	0.006 ± 0.0	0.102	U	U	U	U	U	U	0.007 ± 0.00
Hexanal	U	U	0.0007 ± 0.0	0.001	U	U	U	U	U	U	0.001 ± 0.00
Phenylacetaldehyde	U	U	0.01 ± 0.0	0.077	U	U	U	U	U	U	0.009 ± 0.00
Furfuraldehyde	U	U	U	0.019	U	U	U	U	U	U	U
3-Methylpropionaldehyde	U	U	U	0.017	U	U	U	U	U	U	U
Diacetyl (2,3-Butanedione)	U	0.03± 0.00	0.008 ± 0.0	0.016	U	U	<0.01	0.21 ± 0.03	0.05 ± 0.01	0.03 ± 0.00	0.008 ± 0.00
2,3-Pentanedione	U	U	U	0.002	U	U	<0.01	U	U	U	U
Notes and Referances	30 L scale [92]	2 L Scale [10]	25 L [36]	75 mL [89]	30 L scale [92]	30 L scale [92]	60 L Scale [5]	2 L Scale [10]	2 L Scale [10]	2 L Scale [10]	25 L [36]

U- Undeclared; ND-Not Detected; ± indicates the standard deviation.

Table S4. Comparison of selected volatile compounds in NABLAB beers produced with some maltose-negative yeasts for the production of special beer types (mg/L)

Compound	***S. cerevisiae* ERS1**	***T. delbrueckii* KBI 22.2**	***T. delbrueckii* T10/T13**	***K. servazzii* C-191027**	***P. fermentans* VTT C-191032**	***P. fermentans* VTT C-191032**	***P. fermentans* VTT C-191033**	***H. uvarum VTT* C-191029**	***W. anomalus* DiSVA2***
Acetaldehyde	16.04± 1.60	9.1 ± 0.4	U	3.76 ± 0.08	2.34 ± 0.00	1.5 ± 0.1	1.7 ± 0.1	1.8± 0.1	49.3 ± 2.8
n-Propanol	6.68 ± 0.16	2.9 ± 0.5	3.03/4.13	2.14 ± 0.06	0.27 ± 0.01	0.6 ± 0.0	0.8 ± 0.0	0.7 ± 0.0	22.5 ± 0.9
Isobutanol	U	4.9 ± 0.1	2.36/3.56	U	U	U	U	U	10.8 ± 1.3
Isoamyl alcohol (3-methylbutanol)	33.63 ± 1.11	10.4 ± 0.3	25.26/29.10**	17.01±0.3	8.65± 0.02	16.5 ± 0.1	17.3 ± 0.3	16.3 ± 0.4	51.6 ± 4.1
2-phenylethanol (β-Phenyl ethanol)	5.78 ± 0.31	U	15.83/13.9	ND	2.77 ± 0.09	5.4 ± 0.7	6.0 ± 0.5	5.1 ± 0.1	0.00 ± 0.00
Ethyl butyrate	U	U	U	U	U	U	U	U	0.040 ± 0.042
Ethyl acetate	4.76 ± 0,26	0.77 ± 0.02	2.23/5.33	0.83 ± 0.03	ND	0.5 ± 0.0	0.3 ± 0.0	1.0 ± 0.1	1.7 ± 0.7
Isoamyl acetate	U	<0.1	U	U	ND	U	U	U	0.051 ± 0.049
Phenylethyl acetate	0.20 ± 0.01	U	U	7.39 ± 0.19	ND	ND	ND	ND	0.061 ± 0.035
3-Methylbutylacetate	0.67 ± 0.06	U	U	0.02±0.002	0.27± 0.01	ND	ND	0.01 ±0.00	U
Ethyl hexanoate (ethyl caproate)	0.18 ± 0.03	U	U	ND	ND	ND	ND	ND	0.056 ± 0.014
Ethyl octanoate (Ethyl caprylate)	0.27 ± 0.09	U	U	ND	ND	0.01 ± 0.01	0.01 ± 0.00	ND	U

Ethyl decanoate	0.06 ± 0.01	U	U	ND	ND	ND	ND	ND	U
Diacetyl	U	0.06 ± 0.01	0.13/0.1	U	U	U	U	U	U
Ethly formate	U	0.90 ± 0.05	U	U	U	U		U	U
4-vinylguiacol	U	U	U	U	U	U	U	U	U
2-methylbutanol	11.01± 0.36	U	U	4.07±0.08	2.10±0.02	4.3 ± 0.0	4.0 ± 0.0	4.5 ± 0.1	U
2-methylpropanol	15.28± 0.30	U	U	7.46±0.2	4.87 ± 0.08	13.1 ± 0.0	13.8 ± 0.0	15.0 ± 0.4	U
Linalol	U	U	U	U	U	U	U	U	0.110 ± 0.010 a
***α*-terpineol**	U	U	U	U	U	U	U	U	0.022 ± 0.001
Citronellol	U	U	U	U	U	U	U	U	0.00 ± 0.00
Hexanoic acid	U	U	0.16/0.20	U	U	U	U	U	U
Octanoic acid	U	U	0.36/0.57	U	U	U	U	U	U
Decanoic acid	U	U	0.67/1.13	U	U	U	U	U	U
Notes and Referances	[87] (volatiles in beer) data was obtained from the supplementary file of the article. It can have a potential use in certain special beer production due to its POF(+) character.	[10] (10 L scale) Highest turbidity in beer *Bavarian wheat beer or special beer production	[111] (2 L) *Bavarian wheat beer or special beer production	[6](10 L scale) Lager type yeast due to clean aroma and cold tolerance (Authors suggestion)	[6] (10 L scale) Wheat beer type due to clove like aroma 4-vinyl guiacol (Belgian-German Ale type)	[6] (Lab scale-2 L) (Belgian-German Ale type)	[6] (Lab scale-2 L) (Belgian-German Ale type)	[6] (2 L scale) The distinctive clove-like aroma of 4-vinylguaiacol was reported (Belgian-German Ale type)	*[135] (500 mL scale) ****sour beer production

U- Undeclared; ND- Not Detected; ± indicates the standard deviation.

*Brettanomyces/Dekkera yeasts (mostlu maltose-positive) are used for the production of Bavarian wheat beers (Hefeweizen), but also some maltose-negative yeasts have been considered for brewing like *Torulaspora delbrueckii, Wickerhamomyces anomalus* [174]. For example, due to its complex aroma profile *T. delbrueckii* was used in the traditionally wheat beer (Hefeweizen) production and found to have potential [158,175].

**Given as total amyl alcohols,

*** W. anomalus DiSVA2 could utilize maltose weakly, total alcohol amount of its beer is 1.53%v/v.

****Osburn, et al. [134] suggest *W. anomalus* for sour beer production (strain YH82)