Sour wort concentrate as an efficient alternative to traditional biological acidification or the use of acidified malt

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2014 ASBC Annual Meeting

June 4, Palmer House
Hilton Hotel
Chicago, IL

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Introduction
Actual situation 1/2

To meet the …

… main **consumer need** …

"Perfect taste" is still the main reason for consumers to buy a beer

Assuring taste stability plays another major role

Great Taste

… as well as …

Naturalness

… the actual consumer **trend** …

"Clean labeled" products accompanied with healthier lifestyle has become one of the most popular trends in the beverage and food industry

Mandatory labeling of ingredients list for alcoholic beverages
acc. to Regulation (EU) no. 1169/2011
on the provision of food information to consumers

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Introduction
Actual situation 2/2

… breweries traditionally use acidification of mash and/or wort:

Use of …	Sour malt	Sour wort
Cons	• Only a very small effect on the wort pH • Maximum dosage in the grist load is limited (otherwise sour beer taste)	• Running or installation of a cost intensive, separate fermentation plant • Continuous use of the brewhouse is necessary (ongoing brews)

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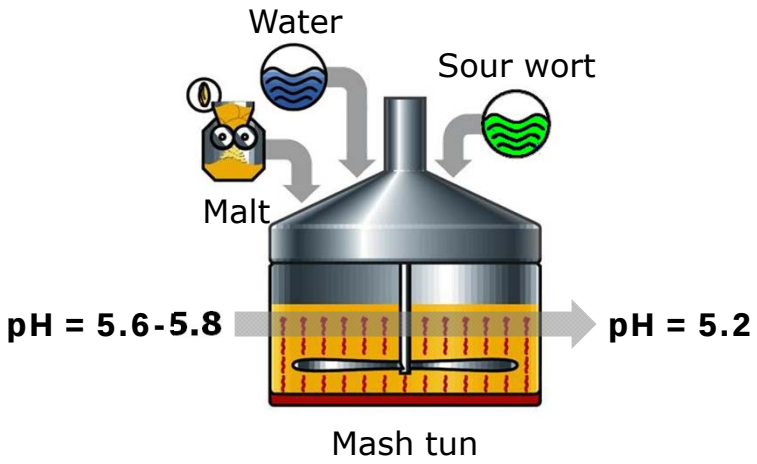
Introduction
Biological acidification with sour wort in the brewhouse [1]

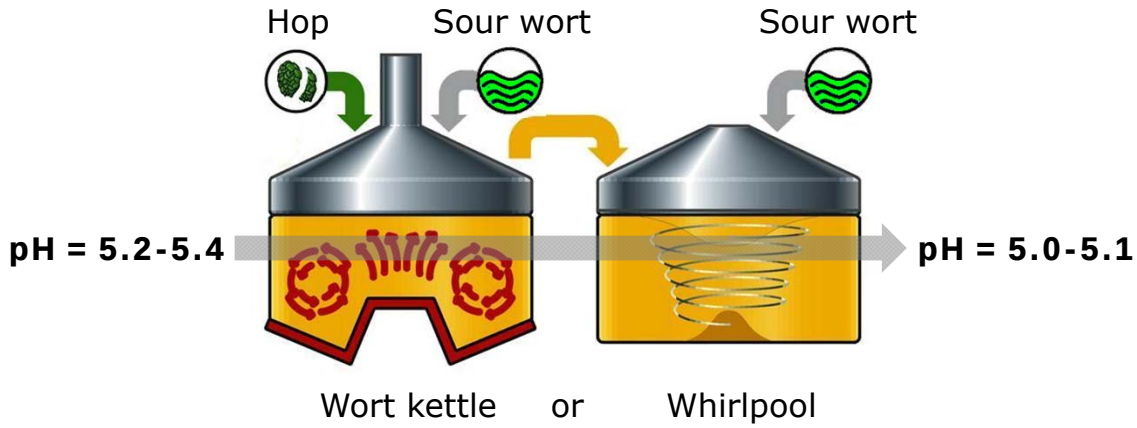
Mash acidification



- Improvement of the activation of enzymes
- More growth promoting substances go into solution
- Inactivation of lipoxygenase
- Lautering proceeds faster
- Strengthening the buffer capacity
- Less formation of staling components

AND / OR

Wort acidification



- Suppressed coloring during wort boiling
- Enhancement of the coagulation of proteins
- More rapid fermentation and maturation
- A softer beer taste
- Reduction of biological susceptibility

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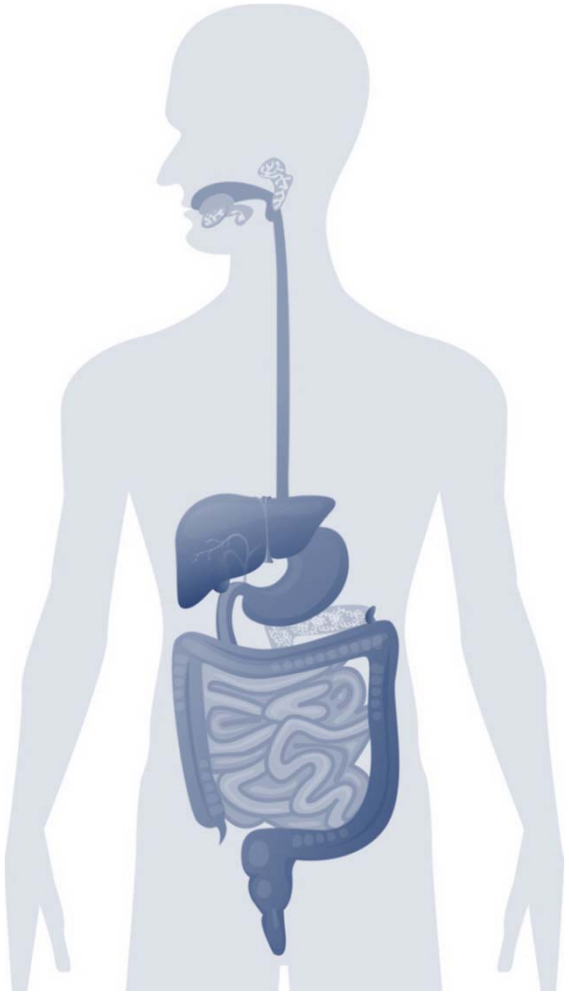
Introduction
Physiological and health advantages [2]

Health benefits

Metabolism: encouragement of the metabolic activity

Digestion: positive impact of lactic acids

Defense mechanism: better protection against illness, pathogenic bacteria is pushed back



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Introduction
Biological acid vs. technical acids [2]

Advantages	Biological acid	Technical acid
	L. amylovorus / L. amylolyticus	Lactic / phosphoric acid
Biological		
Inhibition of some beer spoilage bacteria due to a lower pH in beer	+++	+++
Better fermentation process (attenuation)	+	-
Higher selection pressure of the yeast	++	-
Technological		
Enzyme availability	++	-
Enzyme activation	++	+
Growth promoting substances	+++	+
Coagulation of proteins	+	+
Redox potential	++	+
Fermentation progress	++	+
Filtration	+	(+)
Sensorial		
Softer beer taste	+	-
Aged tasting	++	+
Hop bitterness	+	(+)
Carbonation	+	+
Foam	+	(+)
Color	+	+
Physico-chemical stability	++	++

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Materials & methods
Biological acidification [1]

Production of a stock solution in practice:

- Biologically produced lactic acid by using LAB strains
- Maintain fermentation temperature
- LAB are anaerobic
  → CO_2 atmosphere is preferred
- LAB multiply only at lower lactic acid concentration
  → continuous feed with fresh wort
- Continuous stirring by a jet agitator
- Analysis of the lactic acid concentration during production

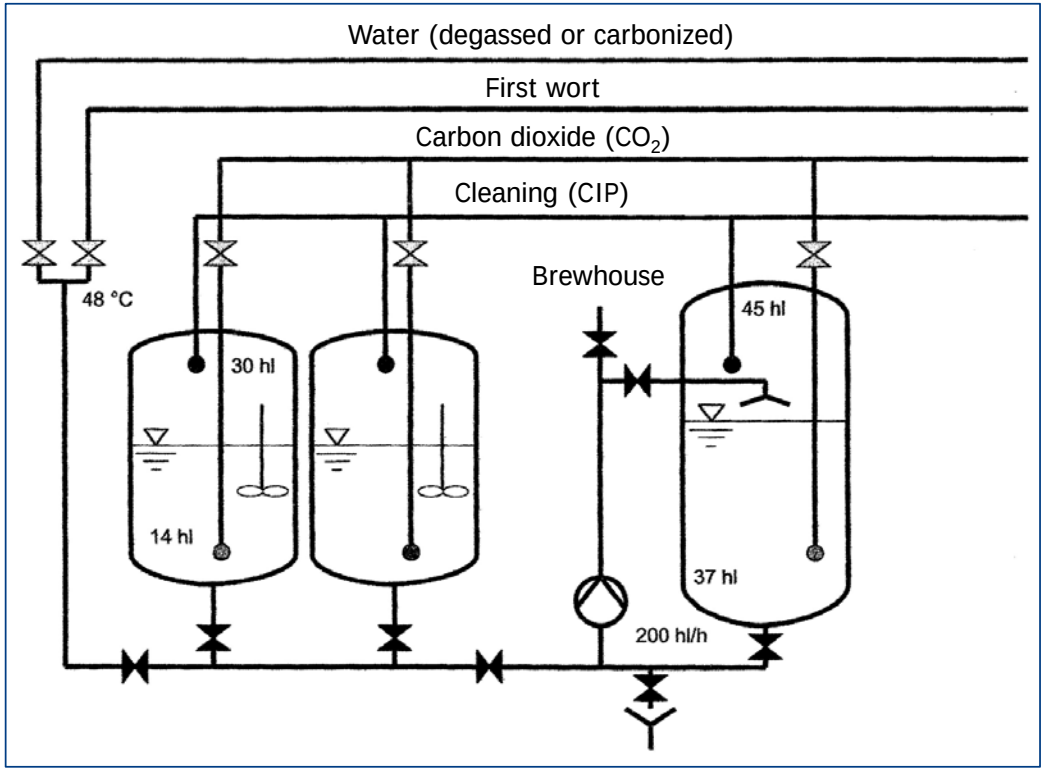


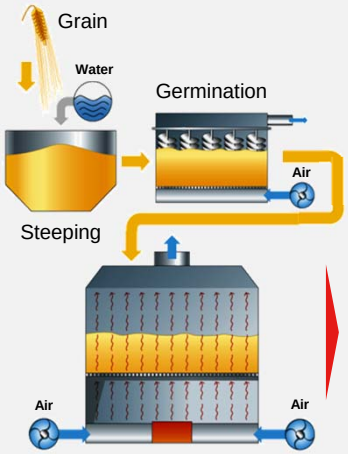
Figure. Biological acidification plant with two fermenters and one storage tank [1].

Materials & methods
Production of sour wort concentrate

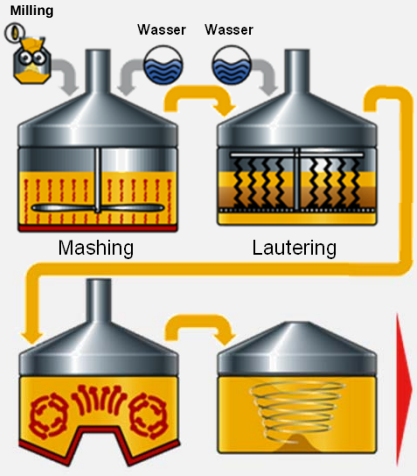
Malting	Wort preparation	Fermentation	Concentration	Filling

Activities

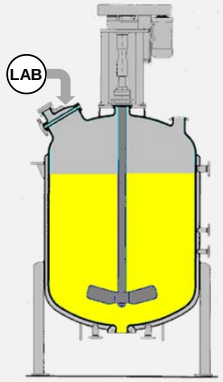
Malt is produced through steeping, germination and kilning to break down cell wall components, partial break down proteins, and generate enzymes.



Using classical mashing methods, the malt grist is brought in solution. With a time and temperature regime soluble and colloidal substances are won as extract. The filtrate, the so called wort, is boiled afterwards.

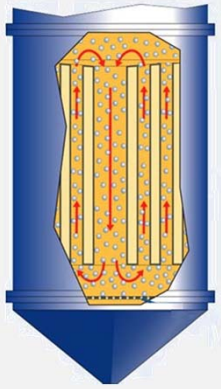


Under CO_2 atmosphere, the sugar in the wort is transferred into lactic acid by pure culture of lactic acid bacteria, e.g. *L. amylolyticus.*



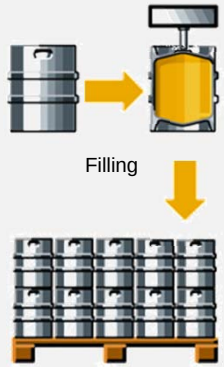
LAB Fermentation

The sour wort is concentrated by performing a soft vacuum evaporation (water evaporation) in order to gain a sour wort concentrate.



Evaporation

With the help of an aseptic filling machine, the sour wort concentrate is filled in optimal packages.



Products

Malt	Wort	Sour wort	Sour wort concentrate

Materials & methods
Specification and advantages of sour wort concentrate

- Standardized product: due to modern fermentation technology a standardized production of sour wort concentrate can be guaranteed
- Easy to handle, no time-consuming (quality-) controls of the biological acidification plant, no CO_2 gassing, no handling with pure LAB cultures in the brewery, etc.
- Enables an easy and convenient dispensing due to optimal packaging units
- High microbiological stability und long shelf-life of the concentrate due to aseptic filling
- Minimal dosage: only 15% of the conventional sour wort amount is needed!

Parameter	Value
Lactic acid	50 g/kg
Density	1.29 ± 0.02 g/cm³
Viscosity	92-182 mPa·s (low dilatancy)
pH	3.0-3.2
Brix	ca. 60°
Gravity	ca. 61 Plato

Materials and methods
Settings of the brewing trials

	Unit	Brew A	Brew B	Brew C
Grist load				
Pilsner malt	kg	2,850	2,850	3,000
Sour malt	kg	150	150	0
Percentage of sour malt	%	5	5	0
Cast wort				
Extract	%	12.0	11.9	12.1
Volume	hl	199	199	198
Sour wort concentrate				
Addition to mash	kg	0	0	51.5
Mash pH	-	5.35	5.36	5.35
Addition to wort	kg	0	57.6	62.2
(Cast) wort pH	-	5.32	5.02	4.98

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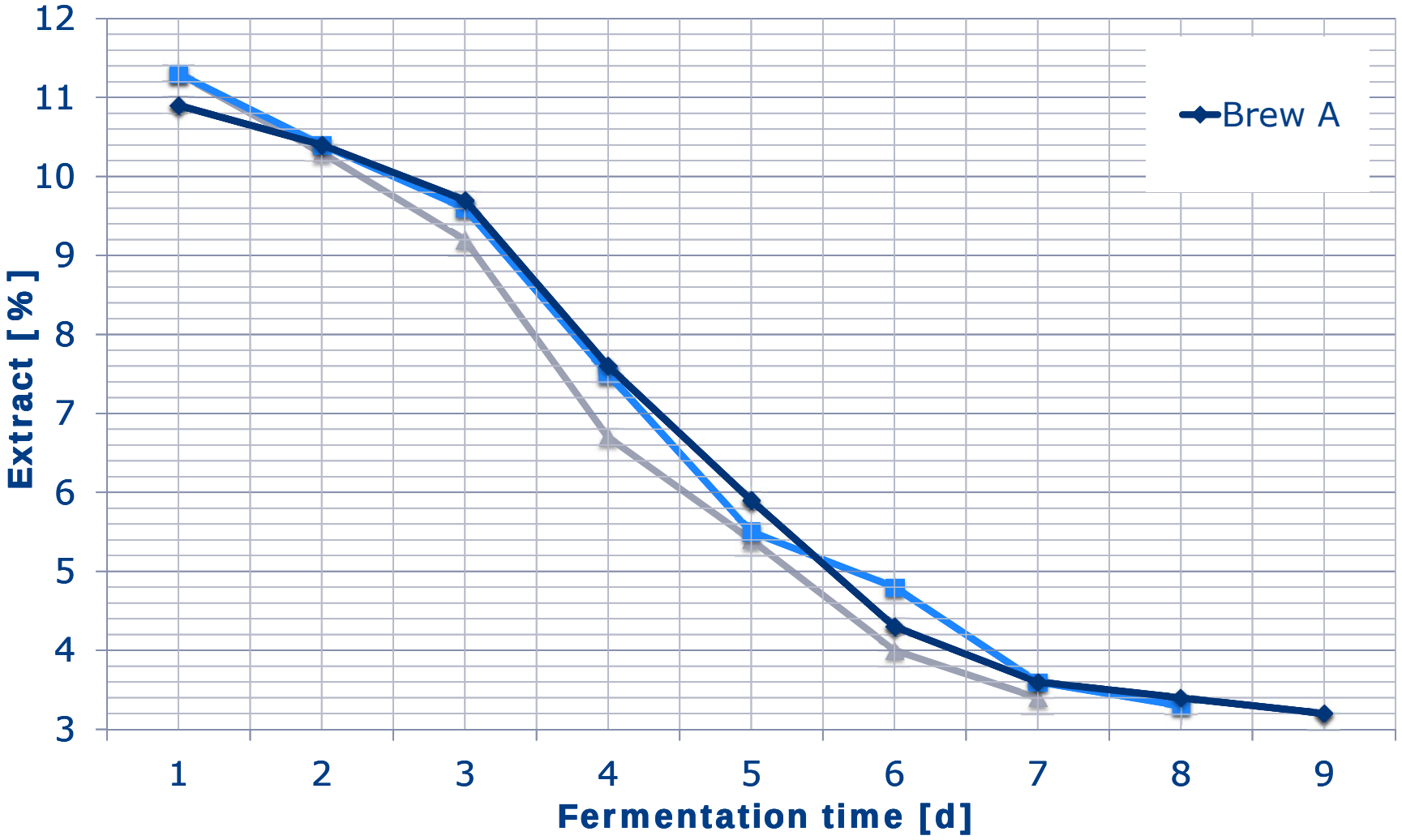
Results & discussion
Wort analyses of the cold wort [3]

Parameter	Unit	Brew A	Brew B	Brew C	Method [4-6]
Extract	% w/w	11.76	11.95	12.03	WBBM 2.9.6.3
pH	-	5.32	5.02	4.98	WBBM 2.13
Colour	EBC	9.50	10.00	9.25	WBBM 2.12.1
Coag. nitrogen[3)]	mg/100 ml	2.65	2.91	2.89	WBBM 2.6.2
TBI[3)]	-	55.31	56.74	48.18	WBBM 2.6.2
DMS free[3)]	µg/l	108.16	97.41	98.75	MEBAK III 1.3
DMS precursor[3)]	µg/l	10.20	22.09	21.95	MEBAK III 1.3
Iso-alpha-acids	mg/l	19.9	19.1	19.3	EBC 7.7

[3)] values recalculated on 12% w/w extract.

Results & discussion
Curves of the extract decrease during main fermentation [3]



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Results & discussion
Beer analyses of the final beer [3]

Parameter	Unit	Brew A	Brew B	Brew C	Method [2]
Original gravity	% w/w	11.78	12.01	12.08	WBBM 2.9.6.3
Alcohol	% v/v	5.22	5.38	5.42	WBBM 2.9.6.3
Extract	% w/w	1.94	1.88	1.88	WBBM 2.9.6.3
Attenuation limit	%	84	85	85	WBBM 2.8.1
pH	-	4.54	4.47	4.37	WBBM 2.13
Colour	EBC	6.25	6.25	5.80	WBBM 2.12.1
Foam SKZ / HLT	sec	114/95	116/96	113/94	WBBM 2.18.4
Bitterness	EBC	16	14.5	13.8	WBBM 2.17.1
TPO (total package oxygen)	mg/l	0.148	0.135	0.133	WBBM 2.28.3
Soluble oxygen	mg/l	0.091	0.087	0.094	WBBM 2.28.1

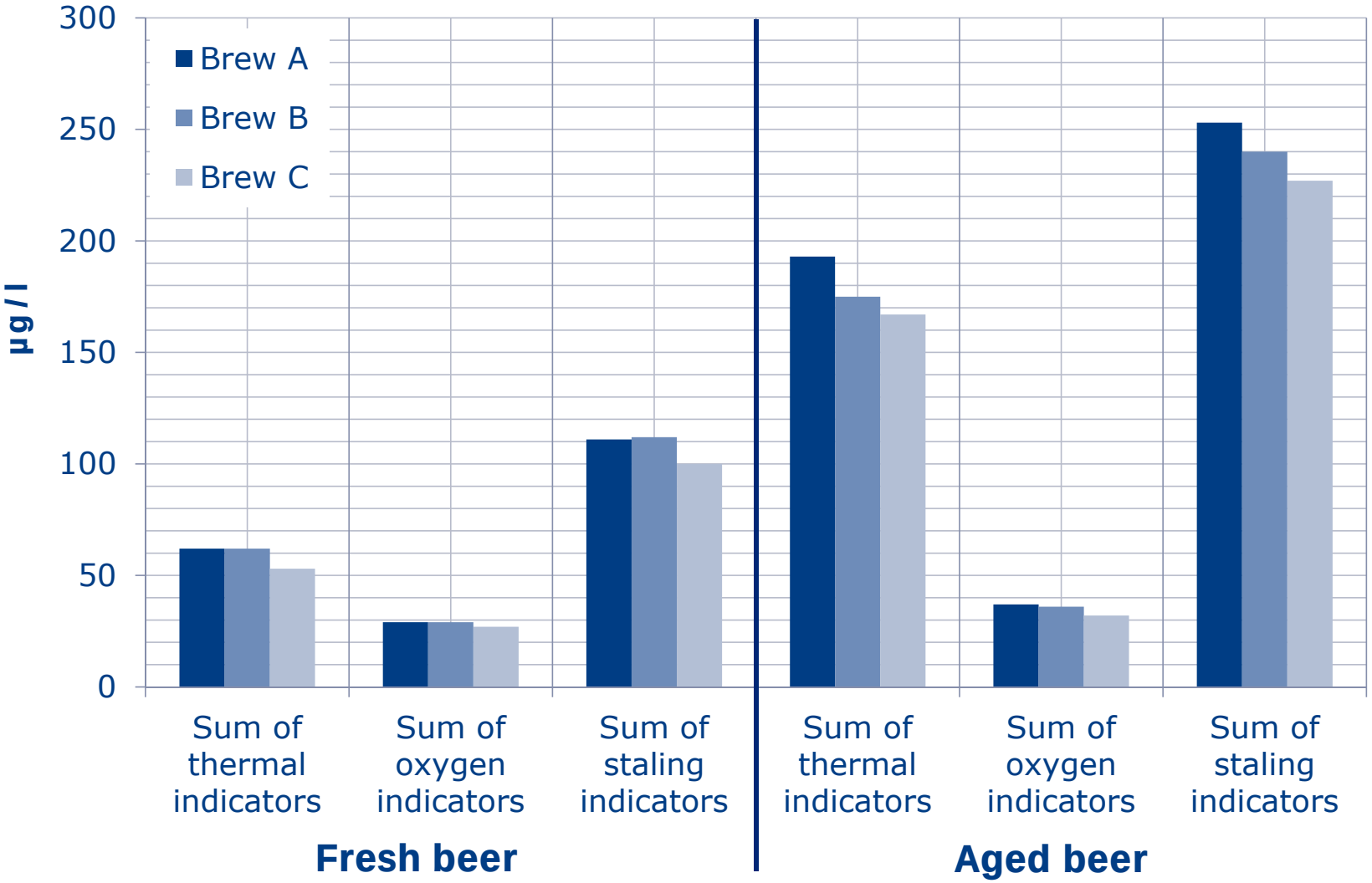
Results & discussion
Concentration of fermentation by-products

Fermentation by-products		Brew A	Brew B	Brew C
Ethyl butyrate	mg/l	0.16	0.17	0.15
Iso-Butyl acetate	mg/l	0.12	0.16	0.14
2-Phenyletyl acetate	mg/l	0.61	0.92	0.89
Ethylcaproate	mg/l	0.17	0.17	0.17
Ethyloctanoate	mg/l	0.31	0.33	0.35
Etyhloctanoate	mg/l	0.03	0.04	0.05
Iso-Valeric acid	mg/l	0.98	0.99	0.90
Hexanoic acid	mg/l	2.1	2.2	2.2
Caprylic acid	mg/l	3.8	4.4	4.1
Decanoic acid	mg/l	0.47	0.68	0.77
Acetaldehyde	mg/l	8.5	10.5	9.9
Ethyl acetate	mg/l	26.3	33.6	32.5
n-Propanol	mg/l	12	12.1	11.7
Iso-Butanol	mg/l	14.3	16.5	16.8
Iso-Amyl acetate	mg/l	3.1	4.2	3.6
Iso-Amyl alcoholes (2-,3-Methyl butanol)	mg/l	60.2	66.7	63.5
Diacetyl, total	mg/l	0.02	0.02	0.01
2,3-Pentandion, total	mg/l	0.01	0.01	0.01
Acetoine	mg/l	1.6	1.6	1.6
2-Phenyl ethanol	mg/l	27.5	32	30.4

Results & discussion
Aging indicators in the fresh and aged beer

		Fresh beer			Aged beer		
		Brew A	Brew B	Brew C	Brew A	Brew B	Brew C
2-Methyl butanal (O, S)	µg/l	6	6	6	6	6	6
3-Methyl butanal (O, S)	µg/l	10	11	10	10	11	10
2-Furfural (T, S)	µg/l	18	17	15	113	104	104
5-Methyl furfural (S)	µg/l	7	7	7	8	7	8
Benzaldehyde (O, S)	µg/l	<5	<5	<5	<5	<5	<5
2-Phenyl ethanal (O, S)	µg/l	13	12	11	21	19	16
Succinic acid diethyl ester (S)	µg/l	5	5	5	<5	5	5
Nicotinic acid ethyl ester	µg/l	11	11	11	20	20	21
Phenylacetic acid ethyl ester (S)	µg/l	<5	<5	<5	<5	<5	<5
2-Acetyl furan (S)	µg/l	8	9	8	10	11	10
2-Propionyl furan (S)	µg/l	<5	<5	<5	5	6	5
Gamma-Nonalacton (T, S)	µg/l	44	45	38	80	71	63
Sum of thermal indicators (T)	µg/l	**62**	**62**	**53**	**193**	**175**	**167**
Sum of oxygen indicators (O)	µg/l	**29**	**29**	**27**	**37**	**36**	**32**
Sum of staling indicators (S)	µg/l	**111**	**112**	**100**	**253**	**240**	**227**

Results & discussion
Compilation of aging indicators of the fresh and aged beer [3]



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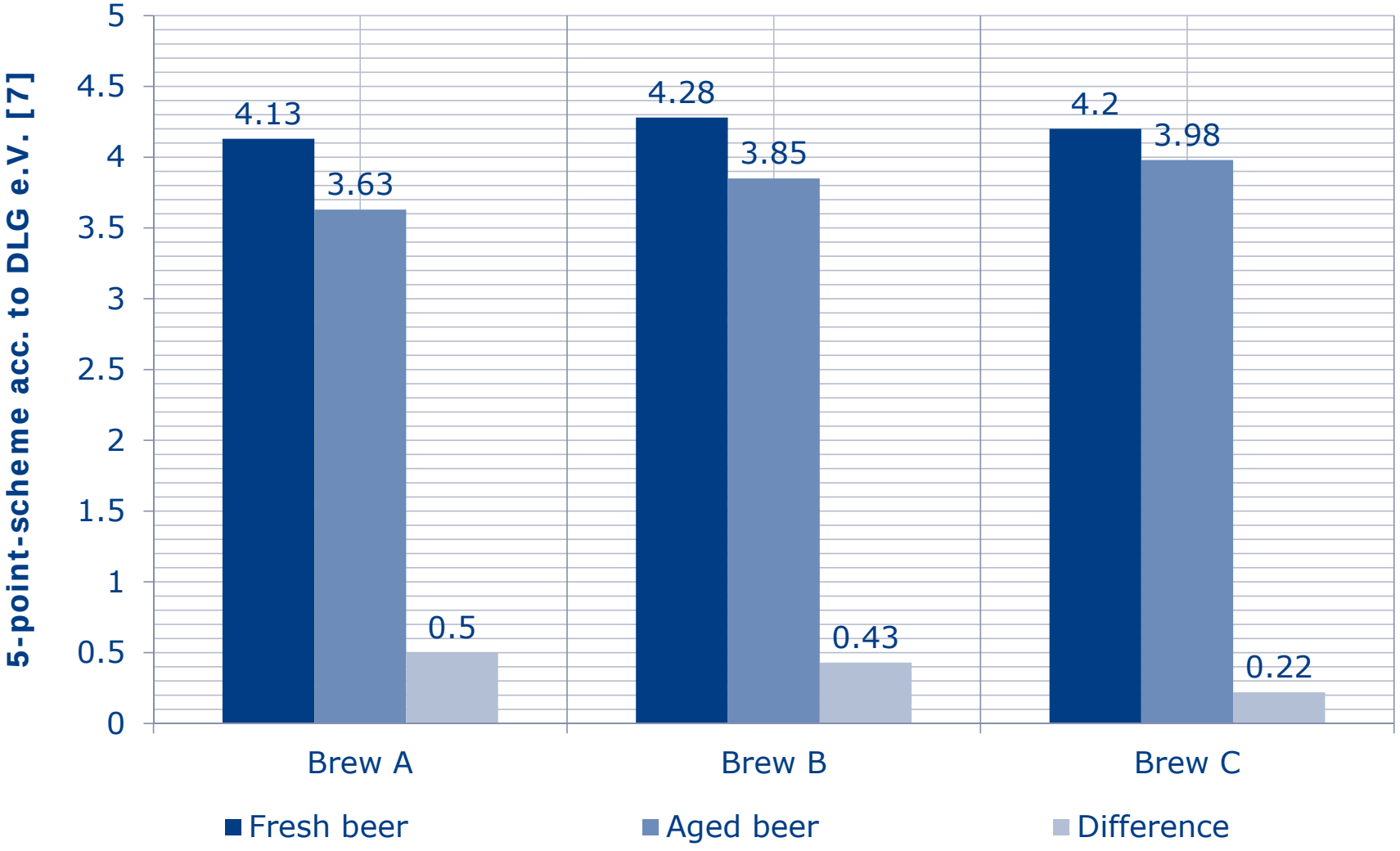
Results & discussion
Results of the tasting panel of Weihenstephan [3]

Parameter	Brew A	Brew B	Brew C
Fresh beer			
Smell	4.0	4.3	4.2
Purity of taste	4.0	4.2	4.2
Body	4.5	4.5	4.5
Carbonation	4.5	4.5	4.5
Quality of bitterness	4.0	4.1	3.9
Beer after artificial aging			
Smell	3.5	3.7	3.8
Purity of taste	3.5	3.7	3.8
Body	4.5	4.5	4.5
Carbonation	4.5	4.5	4.5
Quality of bitterness	3.0	3.5	3.8
Rating beer fresh	4.13	4.28	4.20
Rating beer forced aged	3.63	3.85	3.98
Taste stability	0.50	0.43	0.23

Results & discussion
Taste rating (weighted)



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Conclusion

The acidification with sour wort concentrate …

… has an positive effect on the wort quality.

… results in a quicker fermentation performance.

… leads to a better beer quality in terms of taste and taste stability.

… makes the acidification of mash and wort possible without cost intensive installations.

… is in accordance with the German Purity Law and permits “clean labeling”.

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The authors thank

Mr Josef Englmann

from the

Research Center Weihenstephan

for Brewing and Food Quality

(Technische Universität München)

for his skillful technical and

technological help.

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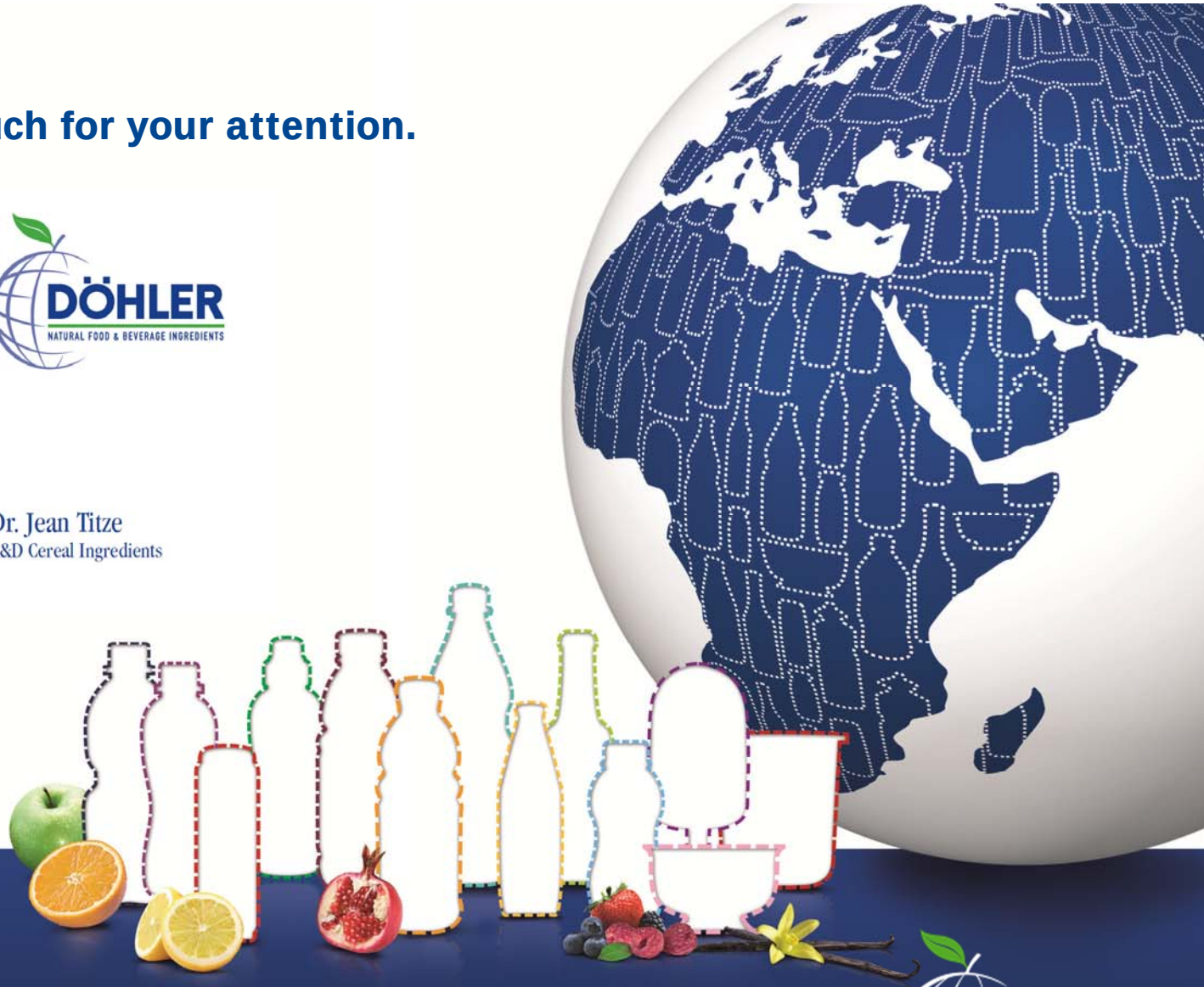

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