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Alcohol-free Wheat Beer: Optimizing the Brewing Process and Product Quality with Sour Wort

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INTRODUCTION

Non- and low-alcoholic beers are on the rise, particularly in Europe. Their global volume increased by more than 20% within the last 5 years (Fig. 1). Alcohol-free wheat beer, for instance, was very successfully established in the market as natural and healthy thirst quencher. A simple and inexpensive method for producing alcohol-free beer (≤0.5% ABV) is the so-called stopped fermentation. In order to achieve a beer-typical character it is, however, essential to adjust the mash and/or wort pH during brewing.The aim of this study was to compare the effect of sour malt (mash acidification) and sour wort (mash and wort acidification) on the brewing process and quality of alcohol-free wheat beer.

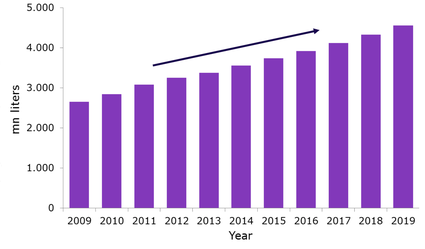

Fig. 1. Global volume of non- and low-alcoholic beers *(Source: Euromonitor International)*.

EXPERIMENTAL

The brewing trials were performed in a medium-sized German brewery. In the first brew, representing the standard procedure in this brewery, a high amount of common sour malt (11.67% of the total grist) was used. In the second brew, both mash and wort were acidified with sour wort, while keeping all other parameters constant (Table 1). The lactic acid concentration in the sour wort used was approximately 55 g/L at a Brix level of 60 °. For adjusting the cold wort pH to a value similar to that achieved with sour malt, a total amount of 280 kg of sour wort has been added during brewing (i.e. 80% of the total amount of sour malt). The beer production process was conducted in a traditional way and in accordance with the German purity law. Worts and beers were analyzed according to standard methods described by Mitteleuropäische Brautechnische Analysenkommission (MEBAK: *Würze, Bier, Biermischgetränke*) and European Brewery Convention (EBC).

Table 1. Brewing materials and acidification procedures.

Materials & Acidification	Unit	Brew with Sour Malt	Brew with Sour Wort
Grist composition			
Wheat/Specialty malt	kg	1,850	1,850
Pilsner malt	kg	800	1,150
Sour malt	kg	350	0
Proportion (sour malt)	%	11.67	0.00
Use of sour wort			
Directly after mashing-in	kg	0	75
Mash pH (20°C)	-	4.31	5.30
Before/after wort boiling	kg	0	205
Wort pH (20°C)	-	4.63	4.58

RESULTS AND DISCUSSION I

Wort Analyses

The targeted adjustment of the mash and wort pH using sour wort considerably improved the overall brewing process, especially in terms of saccharification (iodine normality) and lautering time.
As shown in Table 2, the extract and iso-alpha acid contents clearly increased (optimum pH). On the other hand, the concentration of free amino/coagulable nitrogen decreased. The color was slightly darker with sour wort, whereas the thermal load on wort was reduced.

Table 2. Standard analysis of cold worts.

Cold wort	Method	Unit	Brew with Sour Malt	Brew with Sour Wort
Extract	WBBM 2.9.6.3	% w/w	8.19	8.62
pH-Value	WBBM 2.13	-	4.67	4.60
Color	WBBM 2.12.1	EBC	13.50	15.00
Free amino nitrogen	WBBM 2.6.4.1.2	mg/100 mL	13.64	12.10
Coagulable nitrogen	WBBM 2.6.2	mg/100 mL	4.0	1.3
Thiobarbituric acid number	WBBM 2.4	-	91.8	88.0
Free dimethyl sulfide	WBBM 2.23.1.1	µg/L	<10	<10
Iso-alpha acid	EBC 7.7	mg/L	15.1	18.6

Beer Analyses

Table 3. Standard analysis of bottled alcohol-free wheat beers.

Alcohol-free wheat beer	Method	Unit	Brew with Sour Malt	Brew with Sour Wort
Apparent extract	WBBM 2.9.6.3	% w/w	6.62	7.32
Alcohol	WBBM 2.9.6.3	% v/v	0.48	0.24
Apparent degree of fermentation	WBBM 2.9.6.3	%	12.5	6.0
pH-Value	WBBM 2.13	-	4.69	4.69
Color	WBBM 2.12.1	EBC	11.50	11.50
Bitterness units	WBBM 2.17.1	EBC	13.2	15.7
Total oxygen (bottled beer)	WBBM 2.28.3	mg/L	0.02	0.04
Foam stability (SKZ)	WBBM 2.18.4	sec	111	115

Nevertheless, the sensory quality of the fresh alcohol-free wheat beer produced with sour wort was rated higher as regards aroma, purity of taste, fullness of body, and quality of bitterness achieving an overall score of 4.55 out of 5.0 (Fig. 2). Furthermore, the targeted mash and wort pH adjustment using sour wort also led to a considerably better flavor stability compared to the use of sour malt.

After a short fermentation period at around 22°C, the sour malt brew was blended with 16 hL of water and the sour wort brew with 26 hL before bottling. This resulted in a far lower alcohol content in the latter product (Table 3).

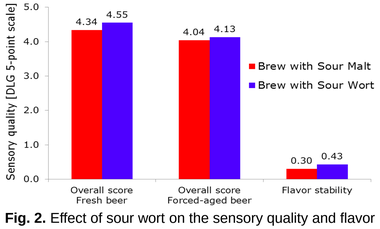

Fig. 2. Effect of sour wort on the sensory quality and flavor stability of alcohol-free wheat beer.

RESULTS AND DISCUSSION II

As shown in Fig. 3, the fresh and forced-aged alcohol-free wheat beers brewed with sour wort exhibited significantly lower levels of heat indicators (2-furfural, γ-nonalactone) as well as oxygen indicators (2-phenylethanal), resulting in a reduction of staling components by 34.7% and 48.6%, respectively, in comparison to the respective alcohol-free wheat beers produced with sour malt. In a descriptive sensory evaluation, the aroma/flavor of the sour wort brew was perceived as *pure, full-bodied, and lively* with a *pleasant top-fermented note, a pleasant slight note of caramel, and balanced aftertaste* (sour malt brew: *pure, thin-bodied, lively, slight top-fermented note, balanced aftertaste*). After the forced-aging process, the sour wort beer was described as *still pure* in contrast to the sour malt brew. Furthermore, the foam (visual) of the sour wort brew was found to be *very good* (sour malt brew: *good*).

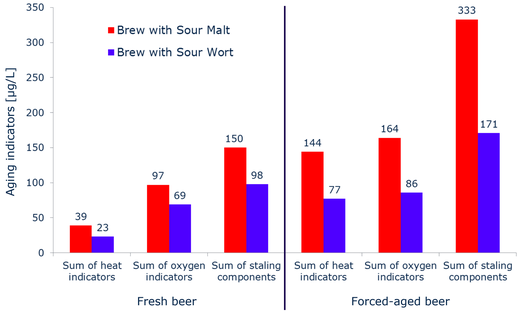

Fig. 3. Effect of sour wort on aging indicators in fresh/forced-aged alcohol-free wheat beers.

CONCLUSIONS

This study clearly shows that the substitution of sour malt (mash acidification) with sour wort (mash and wort acidification) in the production of alcohol-free wheat beer by stopped fermentation not only considerably improves the overall brewing process but also results in a superior product quality as regards taste and flavor stability. In addition, the use of sour wort has the potential to increase the production output or to reduce the total material input.

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