The Control of Beer Production by Anti-Oxidative Indexes


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ABSTRACT

In a series of experiments to establish an anti-oxidative brewing system, attempts were made to introduce quantitative indexes to optimize mashing and other processes. First of all, analytical systems were optimized to describe the brewing process and the staling rate of the resulting beer, to enable the proper process control from mashing to fermentation. It was confirmed quantitatively that the optimal operation resulted in the production of wort with higher anti-oxidative potency, and that bottled beer brewed from such wort was better in the resistance against staling during a longer storage period. This presentation will be focused on the introduction of analytical methods and the control and optimization of the mashing process by employing the indexes of reducing activities. The difference between the laboratory and the production site results will be also discussed.

Keywords: Mash Optimization, Reducing Activity by MEBAK, Mash Agitation Speeds, Reducing Activity by Chapon Test

INTRODUCTION

Among the endeavors to prolong the freshness of beer, the protection of beer from oxygen during processing, and finally in the bottle, has been most promising.

We focused on the intrinsic anti-oxidative capacity of beer originally derived from the raw materials; attempts were carried out to optimize the mashing process, milling conditions and agitation intensity by introducing quantitative indexes. We confirmed quantitatively, the optimal operation that enabled the production of wort with high anti-oxidative capacity; the beer brewed from such wort has a better stability against staling.

EXPERIMENTAL METHODS

1. Pilot brewing
400 L-scale facilities were employed to determine the effect of oxidation during wort preparation, on the quality of beer, against staling phenomena during storage.

2. Laboratory brewing
A 2 L-scale miniature of a brewing vessel was employed to scrutinize the relationship of agitation speed and the oxidation degree of wort. The effect of milling methods on the oxidative degree of wort was also studied with dry milling, wet milling and moist conditioning.

3. Reducing activities
A slightly modified Tannometer (Pfeuffer GmbH, Kitzingen, Germany) was employed.

SINTÉSIS

En una serie de experimentos para establecer el sistema antioxidante de la elaboración de la cerveza, se atentó introducir índices cuantitativos para mejorar la trituración y otros procesos. Primero que todo, se mejoraron los sistemas analíticos para describir el proceso de la elaboración de la cerveza y la velocidad en que se echa a perder la cerveza resultante, para permitir el control apropiado de proceso desde la trituración hasta la fermentación. Se confirmó cuantitativamente que la operación óptima resultó en la producción de mosto con la potencia antioxidante más alta y que la cerveza embotellada elaborada de este mosto fue más resistente a echarse a perder durante un periodo de almacenamiento más largo. Esta presentación se enfocará en la introducción de métodos analíticos y el control y el proceso de trituración óptimo mediante el empleo de índices de actividades de reducción. También se discutirá la diferencia entre los resultados del laboratorio y el lugar de producción.
RESULTS AND DISCUSSION

Anti-oxidative brewing test (CO₂ purge) in 400 L-pilot facilities and the beer thus produced.

During wort production processes, all the headspaces of vessels were purged with gaseous carbon dioxide to insulate the mash and wort from air. The oxygen was monitored and kept below 1% in the headspace of vessels.

1) As shown in Fig. 1, the melanoidins derived reducing activity by MEBAK were consistently higher for the CO₂ purge test sample (i.e. anti-oxidative brewing) than for conventional mashing from the mash to the finished beer.

2) The reducing activity derived from polyphenols determined by the Chapon test is summarized in Fig. 2. The time course of this activity increase was almost similar to that of MEBAK.

3) The increase and decrease in the concentration of tannoids is shown in Fig. 3. This Figure shows the concentration, not the reducing activity, of PVPP reactive polyphenols. This fraction increased by 10-25% for product made by anti-oxidative mashing compared to product made by the conventional procedure.

ANALYSIS OF BEER

It is doubtful that furfural itself is the culprit of staling flavor, but it was empirically established that the intensity of staling determined by expert panel sensory analysis gave a good correlation with the concentration of furfural (Fig. 4). Figs. 5 and 6 show the rate of furfural synthesis in the beers prepared by the conventional method and by the anti-oxidative brewing method. The results clearly show the reduction of furfural synthesis for the beer produced anaerobically. In other words, the anti-oxidative brewing repressed the furfural synthesis in the beer during storage at 20 or 30°C.
From the sensory analysis, it was also observed that the antioxidative brewing enabled the freshness of beer to be retained (Figs. 7 & 8).

**The effect of agitation intensity by a 2 L.-scale laboratory miniature.**

As the oxidation of mash and wort proved critical for stale-resistant beer production, the optimization of the operation was studied, e.g. agitation speed.

The effect of agitation intensity of mashing on wort was studied at 5 levels of 0, 72, 154, 300, and 600 rpm without air insulation. The concentrations of tannoids over time are shown in Fig. 9. Fig. 10 summarizes the relation of agitation speed to the indexes of MEBAK and Chapon and to the tannoid concentration. The data obtained by anaerobic brewing under N2 gas and by aerobic brewing with forced aeration are also given as reference. The results support the conclusion that agitation at 600 rpm is almost equivalent to forced aeration, while agitation at 72 rpm is similar to anaerobic brewing.

These experiments showed the importance of the control of agitation intensity, regarding the aeration of mash to produce beer that is resistant to staling.
Fig. 11 shows the analytical data of worts prepared by these three milling procedures. MEBAK results were almost same for these three, but Chapon results and Tannoid concentrations which represented the polyphenol constituents of wort are higher in the case of wort prepared from malt milled by dry milling, although the difference is not significantly large. We might well conclude from these experiments that the effect of agitation intensity is much larger than the effect of different milling procedures.
FIGURE 12
Time Course of the Reducing Activity by MEBAK at Different Brewing Facilities.

FIGURE 13
Time Course of Tannoids Concentration at Different Brewing Facilities.

FIGURE 14
Time Course of Reducing Activity (Chapon) Increase at Different Brewing Facilities.

CONCLUSION

Employing these indexes for reducing activities, we succeeded in filling the gap between theory and practice at the production site as well as in the laboratory. That is, by these indexes we are able to clearly evaluate the degree of oxidation of wort at the processes, and the characteristics of facilities, and optimize the controlling procedure. Other analytical results obtained by GC-MS, HPLC, and a newly developed sensory test all supported the improvement obtained by using the “anti-oxidative production system of Sapporo”. As a result, we have realized the production of a beer with increased stability against staling, and based on these production changes and more modifications of production sites, further improvement of stability is anticipated.