MALT PROCESSING TO OBTAIN HIGH GRAVITY WORT FOR RESEARCH APPLICATIONS

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Abstract

A laboratory-scale high-gravity wort production protocol was developed and designed around the nonspecialized equipment. This protocol can be used for almost any research application, including the comparative study of fermentations on the basis of all-malt wort, high-gravity malt wort and high-gravity adjunct wort.
***Key words**: high gravity wort, production, mashing, fermentation.*

Introduction

In traditional brewing, worts of 11 to 12% dissolved solids are fermented to produce beers of 4 to 5% (vol/vol) ethanol. Recently, high-gravity brewing at a limit of 16 to 18% dissolved solids has become popular due to advantages such as increased plant efficiency, reduced energy, labor and capital costs, use of higher adjunct ratios, improved smoothness, flavor, and haze stability of beer and increased ethanol yields per unit of fermentable extract (Stewart,1999).

Attempts to ferment worts above 18% dissolved solids have proven to be difficult, largely because of problems with yeast viability and slow and incomplete fermentations (Kirsop,1982).

Both ethanol toxicity (Pratt, 2003) and high osmotic pressure levels (Hammond, 2001) have been implicated as the limiting factors.

Much of the research addressing these and other associated problems is currently confined to breweries that possess the specialized brewhouse equipment needed to produce high-gravity wort.

Consequently, fermentation studies aiming to elucidate the factors responsible for poor fermentation performances are limited to using a single wort type consistent with the particular beer produced by the brewery, or the use of synthetic media, or both.

Furthermore, the most widely used method to prepare high-gravity wort has been to supplement normal-gravity worts with adjuncts.

This has the effect of reducing the concentration of all other wort components, such as minerals, vitamins, and FAN and to introduce additional variables in the experimental design. This effectively restricts the variability and type of research that can be performed as well as limiting the widespread applicability of their studies.

Furthermore, the need for expensive conversion and lautering equipment effectively excludes the general research community from participating in brewing research and impedes the introduction of new technology and novel research concepts into the area.

Moreover, the future progression of research into high gravity brewing would benefit from a comprehensive comparative study involving a variety of wort types.

The aim of this study was to develop a small-scale wort production protocol that is adaptable to the needs of the research laboratory and does not require the use of specialized brewhouse equipment, yet provides the means to produce a variety of wort types (Dawn, 2004).

Experimental

Malted barley was ground in a mill to produce a grist suitable for a mash tun vessel. Mashing and filtration were performed in a stirred, temperature-controlled fermentation vessel fitted with a simple mesh filter (figure 1).

Mashing: Three kilograms of malt grist was mashed into 10 l of preheated water (47°C) and incubated at 45°C with stirring (700 rpm) for 30 min. The temperature was increased over a 20-min period at a rate of 1°C per min. to 65°C.

After a further 40-min hold, the temperature was raised to 76°C at a rate of 2°C per min, and held until filtration was complete. The mash was tested throughout for starch conversion using the iodine starch conversion test.

Hop boiling: Upon completion of the wort recycling stage, the mash tun was dismantled and cleaned. The spent grist was removed from the filter mesh, and the filter mesh was cleaned.

The mash tun was reassembled, and 1 kg of spent grist was added back into the mesh filter. The filtered wort was transferred back into the mash tun vessel and heated to 100°C. Hop pellets (1.6 g/l) were added, and the wort was boiled for 1 hr with an evaporation rate of *8%* per hour.

Wort analysis: The quality of the wort produced was assessed with the following parameters: pH, original extract, attenuation limit, color and extraction efficiency.

Fermentation conditions: A starter culture was transferred to 400 ml of wort in 1l Erlenmeyer flasks and incubated for 72 hr at 30°C. Yeasts were harvested by centrifugation (5000 rpm for 15 min at 20°C; in sterilized centrifuge tubes. Fermentations were carried out in a 10l fermenter.

Specific gravity and viability measurements. Specific gravity was measured with a hydrometer, and yeast cell numbers and viability were measured with a counting chamber and with methylene blue staining.

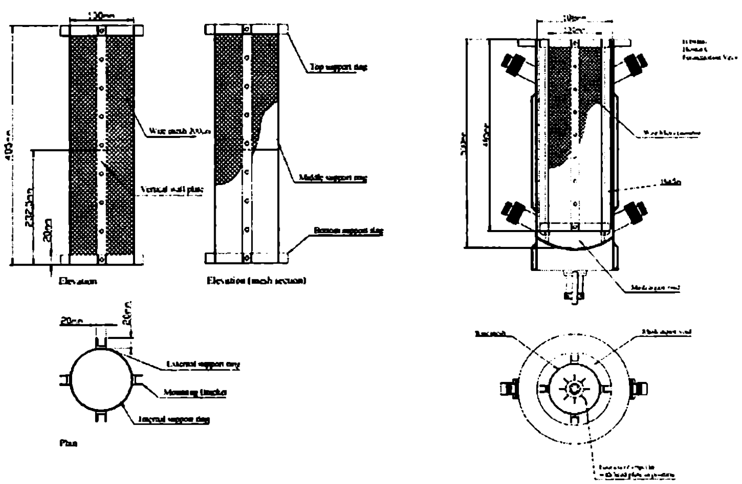

Fig. 1: Schematic representation of conversion vessel and mesh filter configuration

The summary of wort production protocol is represented in figure 2.

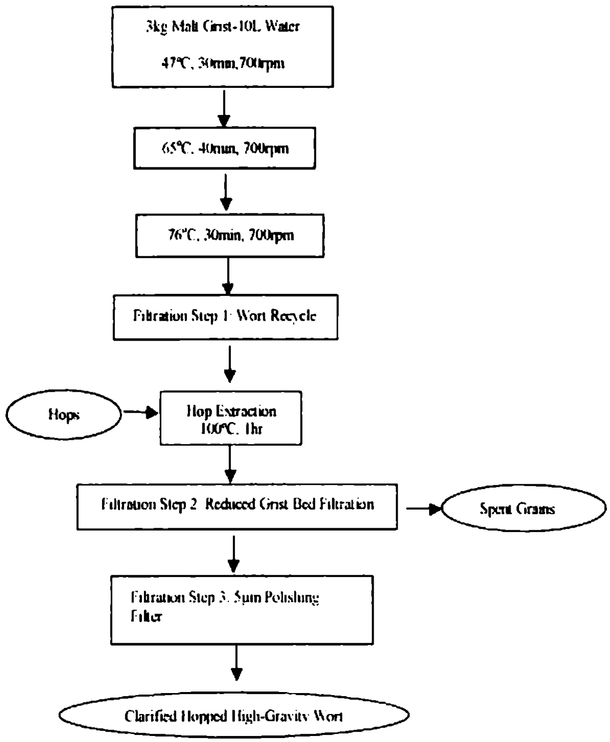

Fig. 2: Summary of wort production protocol

Results and Discussion

As already stated, the primary aim of this wort production protocol was to produce a consistent and fermentable high-gravity wort product that provided sufficient nutrients to support yeast fermentation and allow for its subsequent attenuation. The apparent attenuation limit was used as a parameter to assess the fermentability and quality of the wort. The wort produced was found to have an apparent attenuation limit of 73% and subsequent fermentation studies showed complete attenuation after 84 hr (figure 3). Figure 3 shows the metabolic utilization of the wort produced when fermented with the yeast *Saccharomyces cerevisiae*. The resulting fermentation profile is typical of the high-gravity wort produced. The rate of sugar utilization increased exponentially for the first 20 hr with a concomitant increase in yeast cell number and ethanol production. The wort pH dropped from an initial value of 5.01 to approximately 4.11. Wort produced was shown to be consistent and fermentable providing sufficient nutrients for yeast growth and metabolism.

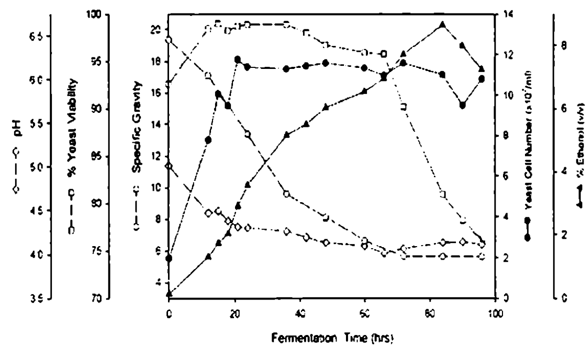

Fig. 3: Data from small - scale fermentation

Conclusion

A mash with a water/grist ratio of 3.3:1 produced a wort with a specific gravity of at least 22.74°P with an extraction efficiency of 89.7% in less than 335 min.

Furthermore, the wort was shown to be fermentable, having a 73% attenuation limit when fermented with *Saccharomyces cerevisiae*. The wort produced had an average pH of 5.01 and a color of 33.85 EBC units.

A laboratory-scale semiautomated wort production protocol was designed and developed around nonspecialized laboratory equipment to produce a consistent fermentable high-gravity wort product.

This protocol can be easily adapted to the needs of a particular laboratory or research group and allows for the production of a variety of wort types. This will allow for a comprehensive comparative study of a variety of wort types.

Furthermore, this protocol will help democratize brewing research, making it more accessible to the general research community and hence, will allow for the introduction of new technology and novel research concepts into the area.

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