IS WORT BOILING NECESSARY?*

By H. Rennie
(*Brewing Industry Research Foundation, Nutfield, Redhill, Surrey*)

Received 8th October, 1971

Experiments are described in which the boiling of wort is replaced by a hold at 85° C, and the effects upon beer quality are reported. Beers with normal shelf-life and sound flavour can be produced without the wort having been boiled.

Introduction

The commonly quoted reasons for the vigorous boiling of wort are: (i) to extract bitter and other substances from hops and promote necessary chemical changes; (ii) to precipitate unwanted nitrogenous material; (iii) to terminate enzymic action; (iv) to remove undesirable volatile compounds; (v) to sterilize the wort; and (vi) to evaporate excess water.

Consideration of these reasons shows that in every case the same objective can be achieved by a method other than vigorous boiling. The use of post-fermentation bittering removes the need for extracting hops in the copper. It has been shown by Hudson & Birtwistle[1] that there is no relationship between bright worts at the copper stage and good shelf life of the subsequent beer. Sandegren[2] was of the opinion that boiling tended to form a haze precursor material which could be carried forward into the beer. Enzyme action is stopped at temperatures below the boiling point of worts. The removal of volatile components of wort is done very successfully by boiling, but boiling is a non-discriminatory process which can remove the desirable volatiles as well as the undesirable. The sterilizing of wort can be carried out below boiling point. Manipulation of mash tun run-off can eliminate the need for large-scale evaporation of water in most cases.

The above considerations led to a series of trials designed to determine the effect on beer quality of a hold period at a selected temperature as compared with the normal boiling procedure.

Experimental

Wort production.—The method of wort production was as described by Hudson & Birtwistle.[1] The malt used in these trials was produced commercially and contained 1·4% of nitrogen. The mashing temperature was 65·5° C (150° F).

Wort temperature hold.—Sweet worts were held at 85° C (185° F) with hop extract (12·5 g, 40% α-acids/59·5 litres) in a steam jacketed vessel open to the atmosphere and were stirred throughout the hold period, which was 90 or 15 min. Addition of hop extract was used in these trials to minimize possible change in fermentation pattern which might have resulted from the use of unhopped wort. It was realized that addition of hop bitter materials to the copper under these conditions would be uneconomic.

Wort boiling.—Control worts were boiled as described by Hudson & Birtwistle.[1]

Fermentation.—A similar procedure to that described by Hudson & Birtwistle[1] was used, except that beers at rack were neither filtered nor repitched. Conditioning, cold storage and bottling conditions were similar to those described by the above authors.

Results

Wort held at 85° C (185° F) for 90 min.—A comparison was made between beers whose worts had been boiled normally for 90 min and beers made from worts which had been held at 85° C (185° F) for 90 min in the copper. Table I gives wort and beer analyses for these trials.

The unboiled wort and the derived beer were slightly lower in colour, higher in total nitrogen, and lower in bitter substances, than the control. Shelf life was 4 weeks less than in the case where wort was boiled in the normal way. Flavour differed from that of the beer from boiled wort but was still sound in character.

Thin layer chromatography indicated that

* Based on a lecture delivered to the London Section of the Institute of Brewing on 5th April, 1971.

the spectrum of bitter substances was similar in control and experimental beers. Utilization was lower in the experimental worts and beers, as anticipated, but the lower value in the worts was partly compensated by lower loss on fermentation. Moreover the lower analytical bitterness of the experimental beer was masked by a higher level of hop oils.

TABLE I

EFFECT OF REPLACING WORT BOILING BY AN 85° C HOLD

	Standard boil*	85° C hold*
WORT		
pH	5·06	5·20
Colour (°EBC)	11·5	10·0
Total nitrogen (mg/100 ml)	74·9	79·4
Amino nitrogen (mg/100 ml)	19·4	19·0
Bitter substances (mg/litre)	45·9	37·5
BEER		
pH	3·82	3·84
Colour (°EBC)	11·0	9·0
Total nitrogen (mg/100 ml)	43·9	47·2
Amino nitrogen (mg/100 ml)	3·7	3·7
Bitter substances (mg/litre)	20·9	16·3
Head-retention (sec)	95	96
Shelf-life (weeks)	16	12

* For a period of 90 min.

Wort held at 85° C (185 °F) for 90 min, pH adjusted to 4·9.—In this trial the wort pH was adjusted with sulphuric acid to 4·9. Table II gives average analytical figures for the worts and beer. Values are fairly similar to those in Table I with slight additional loss of bitter substances as would be expected from the lower pH in the copper. The flavour of these beers was found to fall in the middle of the commercial range when they were taste-tested using a ranking trial. Hop character was more pronounced than in the control beer.

TABLE II

EFFECT OF REPLACING WORT BOILING BY AN EQUIVALENT PERIOD AT 85° C AFTER ADJUSTING WORT pH TO 4·9

	Standard boil	pH 4·9 85° C hold
WORT		
pH	5·15	4·90
Colour (°EBC)	11·0	11·0
Total nitrogen (mg/100 ml)	75·2	79·1
Amino nitrogen (mg/100 ml)	18·1	18·9
Bitter substances (mg/litre)	43·2	36·5
BEER		
pH	3·82	3·76
Colour (°EBC)	11·0	9·0
Total nitrogen (mg/100 ml)	45·0	46·1
Amino nitrogen (mg/100 ml)	3·7	3·3
Bitter substances (mg/litre)	22·3	15·8
Head-retention (sec)	97	92
Shelf-life (weeks)	16	16

The shelf life of beers treated in this way was found to be at least as good as, and sometimes better than, the shelf-life of control beers produced from normally-boiled worts.

Wort raised to 100° C, cooled to 85° C, and held at 85° C.—Wort with pH adjusted to 4·9 was heated to 100° C and then allowed to cool to 85° C and held at that temperature. Cooling from 100° C to 85° C took about 50 min and the temperature was then maintained at 85° C for a further 40 min before casting. Wort and beer analyses are given in Table III.

The raising of the temperature to 100° C prior to holding at 85° C resulted in a wort with lower total nitrogen but this difference was not carried through to the final beer.

TABLE III

EFFECT OF RAISING WORT TEMPERATURE TO 100° C PRIOR TO HOLD AT 85° C (pH ADJUSTED TO 4·9 IN BOTH)

	pH 4·9 85° C Hold	pH 4·9 Raised to 100° C Held at 85° C
WORT		
pH	4·81	4·91
Colour (°EBC)	10·0	11·5
Total nitrogen (mg/100 ml)	79·0	74·0
Amino nitrogen (mg/100 ml)	19·9	19·5
Bitter substances (mg/litre)	33·7	39·8
BEER		
pH	3·72	3·79
Colour (°EBC)	9·5	9·0
Total nitrogen (mg/100 ml)	45·3	46·4
Amino nitrogen (mg/100 ml)	3·6	3·3
Bitter substances (mg/litre)	15·9	18·3
Head-retention (sec)	92	89
Shelf-life (weeks)	16	12

Bitter substances in both wort and beer show that the period of higher temperature favoured increased utilization of hop bitter substances, though the difference was not so great as might have been expected. In aroma, the beers where wort had been raised to 100° C lacked hop character, presumably through increased loss of hop oils. There was a significant reduction in the shelf-life of the beer.

Reduction of hold time to 15 min.—Adjusting pH to 4·9 and then holding the wort for 15 min at 85° C did not produce significant differences in analytical values with the exception of shelf-life which was found to be 10 to 12 weeks compared with a value of 16 weeks for a 90-min hold.

The flavour of the beers where worts had been held at 85° C for only 15 min was found to be less acceptable, hop character being too pronounced for most tastes.

Discussion

These trials show that shelf-life of beers made from unboiled wort can be as long as that of beers from normally boiled wort. The shelf life of the beer produced from wort held at 85° C for 15 min is 10–12 weeks, which is adequate for many purposes.

These results may at first sight appear to be a contradiction of traditional experience which insists on a vigorous boil to achieve good shelf-life. However, it should be remembered that agitation of the wort has been shown[1] to play an important part in improving shelf life. Agitation is in practice usually achieved by boiling vigorously but it does not follow that the temperature may not be lower than boiling point if other means of agitation are available.

It is also significant that beer from wort which has been heated to 100° C before being held at 85° C has a lower shelf life than beer from wort held at 85° C throughout. This would seem to support Sandergren's suggestion[2] that some change takes place in wort composition as the boiling point is approached and that this change promotes formation of additional haze-precursors. It is suggested that to achieve stability these haze-precursors must then be reduced by boiling and agitation.

Lundin fractionation of beers from worts held at 85° C for 90 min, and from worts raised to 100° C and held at 85° C, failed to reveal any difference in the distribution of nitrogen between Lundin fractions A, B and C of the two beers. Thus, quantitative change is either very small or not related directly to nitrogenous components.

The non-boiled worts were very cloudy and yet they produced beers of good shelf-life. This agrees well with the findings of Hudson & Birtwistle[1] that there is no correlation between the brightness of worts from the hop-back and the shelf-life of the beers.

Hop extract was used in the copper in this series of trials to avoid changes in fermentation pattern. The results confirmed the expectation that utilization would be reduced in the unboiled worts, and, if an 85° C hold were to replace boiling of wort, then clearly a more economic way of introducing hop extract (such as post-fermentation hopping) would be required. The amount of bitter materials which passed into the finished experimental beer was, in fact, more than might have been expected considering the relatively low temperature, and of interest is the fact that the spectra of hop-derived substances appeared to be similar in both the experimental and control beers.

Hop oils contributed to a more hoppy character in beers from unboiled wort and while in some the character was too pronounced for most tastes, it did suggest that such a system of wort processing might provide the means for controlling hop character. Some further trials have shown that using a hop rate about 10% of the normal in the copper during the 85° C hold results in a percentage utilization of bitter materials similar to that achieved at the normal hop rate with a normal boil and also gives an acceptable level of hop aroma.

The present work shows that boiling of worts is not an absolute requirement for the production of stable beers of sound flavour. The work suggests that there are possibilities of savings in costs (though savings in steam costs and processing time would be offset by the cost of providing some other means of agitation) and also of control of quality of flavour. These possibilities are being further investigated.

References

1. Hudson, J. R., & Birtwistle, S. E., *Journal of the Institute of Brewing*, 1966, **72**, 46.
2. Sandegren, E., *Proceedings of the European Brewery Convention*, 1947, 28.