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Enzymatic Chillproofing and Beer Foam Stability

Part 1. Foam Deterioration during Manufacturing Processes

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酵素에 의한 除濁操作과 麥酒의 發泡性

第 I 報. 製造工程中의 發泡性傷失

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Abstract

An excellent foam stability in the freshly fermented green beer of a commercial brewery was found to be destroyed substantially by the time it was finished. A further survey proved that the processes of aging and pasteurization accompanied by enzymatic chillproofing were responsible for the foam deterioration.

Introduction

A good, creamy and lasting head of foam that develops as the glass is filled is considered one of the properties of beer appreciated by many consumers. Brewers therefore wish to maintain or improve the foam characteristic of their beers. Many investigations have been carried out to determine the factors influencing head retention. According to Curtis et al.,[1] among the various steps of processes, the largest loss of head retention occurs during fermentation. Thomption et al.[2] think this is due to the loss of foam-stabilizing factors into the foam and to the formation of ethanol, higher alcohols, and other negative foam factors. The use of cereal adjuncts at mashing improves foam stability. The maximum foam is obtained from a grist containing 25% wheat flour and 75% malt but similar improvements can be found using flaked barley.[3] Hop boiling also improves head retention but too prolonged boiling may cause coagulation of the foam-stabilzing proteins.

Despite these findings, relatively little informoiatn is available for the factors involved in the processes following the fermentation. Using a newly developed foam evaluation method each steps of post-fermentation processes have been analyzed in view of the foam stability.

Materials and Methods

Sample beers were taken from various stages on the production line of a commercial brewery. A flow diagram for the beer manufacturing processes following the fermentation step is summarized in Figure 1. About 30 ppm of papain of several commercial blands have been used as chillproofing agents along with certain amount of foam-stabilizing materials in this plant. The foam stability of the beer is expressed with the slope of the foam decay curve obtained through the following procedures originally developed by Hoffmann.[4]

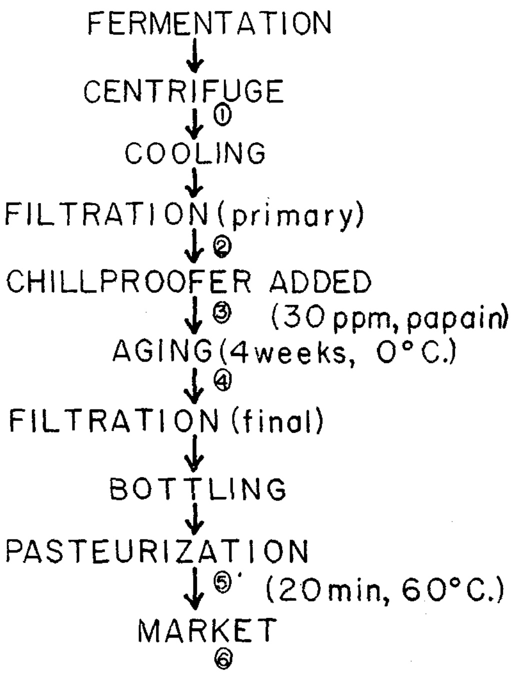

Fig. 1. Flow Diagram of Beer Manufacturing Processes after Fermentation. Circled numericals indicate spots from which beer samples were obtained. For the sample number 6, five bottles of the same product beer were collected from five different retail stores and blended.

About 500 *ml* of sample beer in a beaker is degassed by pouring into another beaker and then back to the original beaker repeating 30 times. After cooling to 5°C. the beer is poured to a 1000*ml* graduated cylinder to the 200 *ml* mark (Fig. 2).

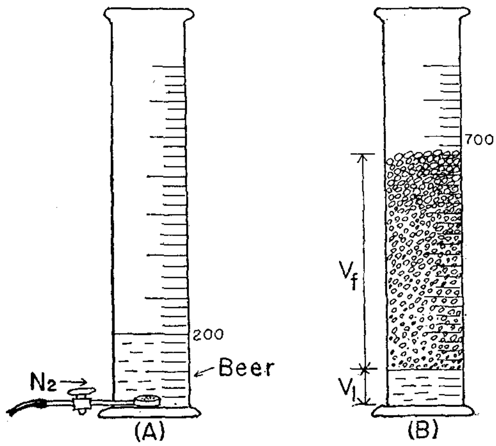

Fig. 2. Foam Measuring Device. Beer is forced to foam by buffling nitrogen gas and then the changes of foam volume (V_f) and liquid volume (V_l) against time are recorded. (A): Before nitrogen gas is buffled. (B): After buffled.

Nitrogen gas is then bubbled into the beer through a fritted glass disc at 1000*ml* per minute rate. The foaming is stopped when the level reaches the 700*ml* mark in the cylinder. The foam volume and liquid volume are then read at one minute intervals for the first ten minutes, and then at five minutes intervals for an additional 40 minutes or until the foam has completely collapsed. All assays were done in duplicate and the values reported are averages. The foam decay curve is obtained by plotting the ratio-volume of foam divided by volume of liquid-versus time on semi-log paper. The stability of a foam is inversely proportional to the slope of the curve.

For the experimental aging 15 liters of green beer was taken from the plant immediately after the primary filtration in a 20-liter aluminum tank. A commercial bland of double-strength liquid papain was added at the level of 30 ppm which is equivalent to the routin operationof the brewery. The beer was then aged at 0°C. for 22 days under the CO_2 atmosphere. Pasteurization at 60°C. for 20 minutes was followed after the beer was bottled. The same procedures were applied for the control beer in which the chillproofer was not added.

Results

The foam decay curves obtained from the fresh green beer and the finished beer are shown in Figure 3. The slope of the finished beer is much

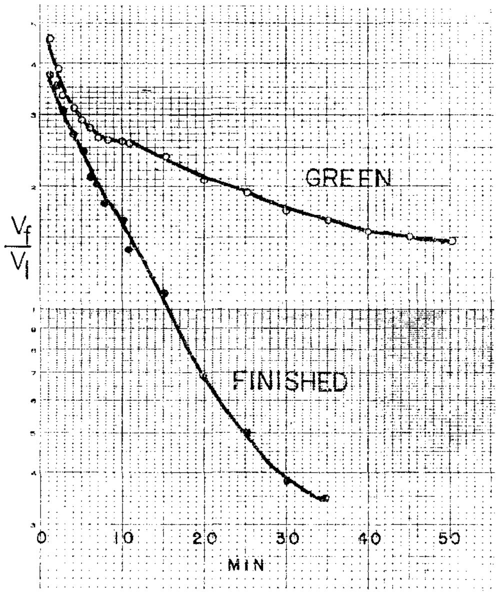

Fig. 3. Comparison of Foam Stability between fresh Green Beer (Green) and Finished Beer (Finished).

steeper than the green beer indicating that the foam stability of the finished beer is much inferior than the fresh one. The fact suggests that some, if not all, steps of the manufacturing processes after the fermentation should be responsible for the foam deterioration. Sample beers were withdrawn from various spots on the production line as shown in Figure 1 and foam decay curves were obtained from each sample. As it is clear in Figure 4 a major part of the foam deterioration takes place during the process of aging. Pasteurization after the aging is also responsible to reach the lowest level of foam stability and no further decrease is detected after the pasteurization. It is

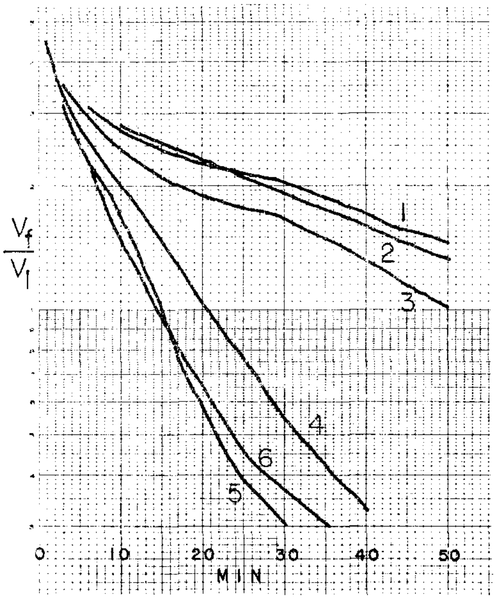

Fig. 4. Effect of Post-Fermentation Manufactu-r ing Processes on Beer Foam Stability. For numericals, see Fig. 3.

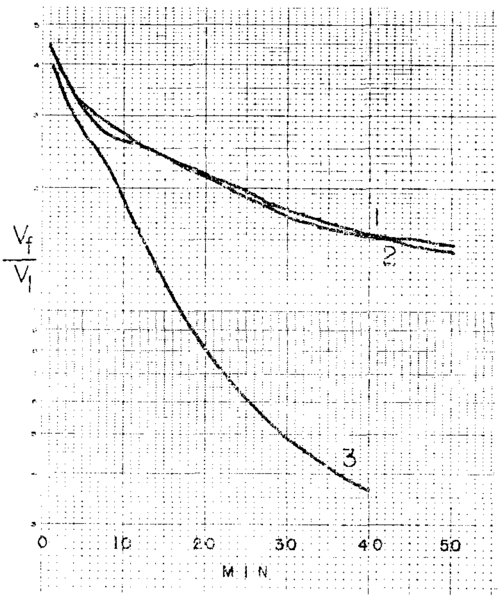

Fig. 5. Effect of Papain on the Foam Deterioration during Aging and Pasteurization. 1; Green beer, 2; Beer aged for 22 days at 0°C without papain and then pasteurized 3; 30ppm papain added and aged for 22 days at 0°C and then pasteurized.

noticeable that a significant reduction of foam stability can be observed imediately after the addition of papain as a chillproofer whereas processes of centrifuge and filtration have no effect on the beer foam quality. In order to confirm the involvement of enzyme on the foam deterioration phenomenon, green beer was aged without papain for 22 days at 0°C. followed by pasteurization, and its foam stability was compared to the beer aged with papain (Fig. 5). Obviously both processes of aging and pasteurization themselves have no adverse effect on the beer foam stability unless the enzymatic chill proofer is participated.

Discussion

A numerous methods have been developed to measure foam quality in beer. Among them the methods commonly employed at present are; the Helm or Carlsberg method[5], the Blom or Tubor method[6], modifications of these methods by Laufer and Schwarz[7] and Laufer and Ziliotto[8], and the Ross and Clark general foam method[9] as applied to studies on beer by Gray and Stone[10]. However, general experience indicates that there is considerable difficulty in obtaining reproducible results. The difficulty, however, has been substantially reduced by using the foam decay curves in the present report. Through the curves we can read the whole pattern of foam behavior, which is the key advantage for this method, from the time when the foam is artificially created until it is collapsed. Because of the nature of non-lineality in the foam decaying pattern, it is rather difficult to judge the foam quality by certain foam volume or collapse rate recorded at any particular stage of the foam decaying process.

Proteolytic enzymes have been universally employed as a chillproofing agent since the time of Leo Wallerstein's invention in 1911[11]. The principle involves the hydrolysis of the complex proteinaceous material in beer which is responsible for the formation of haze. Early studies also established that protein constituents of high molecular weight are needed for head retention[12~15] Since the enzymes of chill-prrofing are not selective for the chill-haze protein, it is natural to assume that the improved colloidal stability imparted by enzymatic proteolysis is accompanied by a decrease in foam stability. The fact has been clearly demonstrated in the present survey in which both aging with papain and pasteurization afterwards are proved to be responsible for the drastic destruction of foam stability in the beer. Although the low temperature of aging may not be favorable for the proteolytic activity of papain, the long period of contact time together with the relatively high concentration of the enzyme would allow the hydrolysis of the protein components responsible for the head retention. The rest of the protein hydrolysis seems to be completed during the pasteurization under more favorable temperature (Fig. 4). At any rate the brewing industry should not insist chillproofing if it is at the expense of foam quality because consumers appreciate good head retention beer as much as the brilliant clear one.

要 約

醱酵直後의 處女麥酒가 갖인 優秀한 發泡性이 製造工程이 끝날 무렵에는 현저히 損失되는 사실을 발견하고 그 原因을 조사한 결과 酵素에 의한 除濁操作을 同伴한 熟成 및 滅菌過程이 麥酒의 發泡性을 크게 傷失시킨다는 것이 證明되었다.

References

(1) Curtis, N.S., A.G. Clark, and P.J. Ogie; J. Inst. Brewing, **67**, 30(1963).

(2) Thompson, C.C., N.S. Curtis, P.E. Gough, and D.J. Ralph;, Proc. Eur. Brew. Conv., Stoclsholm, 305(1965).

(3) Birtwistle, S.E., J.R. Hudson, and I.C. Macwilliam; J. Inst. Brewing, **68**, 467(1962).

(4) Hoffmann, D.R.; Foam Decay Test, Unpublished, Personal Communication (1971).

(5) Helm, E. and C.O. Eichardt; J. Inst. Brew., **42**, 191(1936).

(6) Blom, J.; *J. Inst. Brew.* **43**, 251(1937).
(7) Lafuer, S. and Schwarz, R.: *Amer. Brewer*, **70**, 12, 30(1937).
(8) Lanfer, S. and H. Ziliotto; Amer. Brewer, **72**, 8, 75(1939).
(9) Ross, S. and G. L. Clark; *Wallerstein Lab. Comm.* **2**, 5, 46(1939).
(10) Gray, P. P. and I. Stone; Proc. A. S. B. C., (1940).
(11) Wallerstein, L; U. S. Patents No. 995, 820 and 995, 823-6 (1911).
(12) Davies, J. W., G. Harris, S. Jackson, and R. Parsons,: *J. Inst. Brewing* **62**, 239(1956).
(13) Pierce, J. S., and A. J. R. Purssell,: *Proc. Eur. Brew. Conv.*, Rome, 246(1959).
(14) Anderson, F. B. and G. Harris; *J. Inst. Brewing* **69**, 383(1963).
(15. Sandegren, E. and E. Saverborn; *Int. Tijd. Braurt, Mout.*, 37(1949).