Reduced Effluent Steeping in the Malting Process[1]

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ABSTRACT

In earlier years, no great importance was attached to the amount of water consumption in maltings, but there is now increasing legal pressure to reduce water usage and thus the amount of waste liquids. This investigation was to show the influence of a drastic reduction of the amount of water used in steeping on the quality of malt and beer. A noticeable saving can be achieved only by reuse of steep water or by spraying water on barley during germination. Reuse of steep water (without costly purification and processing) delayed germination and was unsatisfactory. Several pilot tests were made by spraying water on barley in a germinating compartment. The procedure influenced malt and beer quality as follows: The pH and color of the Congress wort rose noticeably (pH plus 0.16, color [EBC] plus 1.1); all other analytical values[2] of the malt remained almost the same. In the brewery, the sprayed malt wort was slower in lautering, and fermented considerably faster. The quality differences of the beer were relatively small. The color increased by 0.5 and the pH by 0.07 units, and the tannin content was reduced by 8 mg/l. All other analytical data were normal. Neither the flavor nor the flavor stability of the beer was affected by this particular malting process.

Key words: *Spray steeping, Steeping, Waste, Water usage.*

While in earlier times water usage in the malting process was of lesser importance, today the malting operations in Europe are forced by law, and by the resulting increased fee rates, to reduce both their water usage and the effluent waste. Although, theoretically, one needs only 0.6 to 0.7 m^3/ton of barley for the required water absorption, in actuality the real use runs much higher. Water usage is very strongly dependent on the method of steeping and on the operating installation. In an economical steeping process, one must count on the following water usage (without recycling of the water):

	m^3/ton
First steep	0.75
Second steep	0.80
Third steep	0.85
Total steep	2.40
Wet transfer	1.0 – 1.5
Total to germination	3.4 – 3.9
Spraying in germinating box	1.0 – 1.2

The single change of steep water, as well as the wet transfer, requires a relatively high water usage. With the spraying method in the germinating compartment, a much lower water usage can be achieved. To reach an even moisture content at all levels in the compartment, one must spray with some 30 to 50% more water than normal. The desired economy is reached only through recycling the steep water and by spraying with or without recycling the water. Recycling the steep water during the steep, without expensive cleaning and preparation, leads to a delay in germination and, therefore, to a poorer modification of the malt (1,3,4,5,6,11). This was also found by Schumann[3]. Thus, in view of the waste cost, spray steeping appears to be the process of the future. In relation to water absorption, the method has positive values since, in every case, an optimal oxygen supply and steeping temperature can be guaranteed, which cannot be so guaranteed with a conventional steeping process. The problems would appear to be more with the diminished (or absence of) cleaning and washing-out during steeping. In connection with spray steeping, a graphic comparison was coined by De Clerck (7) some years ago in a lecture in Berlin: "One becomes as clean with a shower as with a complete bath." This comparison is not exactly correct. It depends on the amount of water used, since when only just enough water necessary for wetting is sprayed, there is no cleaning. Also, washing out the husks and outer layers will be incomplete.

EXPERIMENTAL

Maltings were done either in pilot malteries for 1 kg or in the semicommercial plant for 50 kg in the Versuchs- und Lehranstalt fuer Brauerei in Berlin (12,15,18). A Danish and a German two-row spring barley of the 1974 harvest were used for the experiments.

All results are averages of two separate experiments of both barleys. The malting tests were carried out to the specifications of the middle European analysis commission (MEBAK) (14). Any departure from these specifications is mentioned.

For the 1-kg pilot maltings, steeping was according to five different procedures. The time for water application is shown schematically in Fig. 1. Method A was a flushing procedure with three flushing intervals. In methods B and C, the third or the second and third flushings were superseded by a spraying in the germinating compartment. In method D, the effluent of the first steeping was collected and sprayed for the second and third steeping period. The last process was only a spray steeping without any effluent. The spray steeping always took place in two parts at the beginning and the end of the corresponding steeping time. The steeping and germinating temperature was 14°C (57.2°F).

The brewing experiments were carried out in the pilot brewery with 22 kg of malt. The analyses were done by the method of Krüger and Bielig (13).

RESULTS

Influence of Steeping Process and Amount of Water on Malt Quality

Table I shows the malting data and analysis of the malt. Theoretically, 0.62 m^3 water/ton of barley is needed to obtain a moisture content of about 46.5% in the green malt. For the flushing method (A), the water usage was 2.4 m^3 and the effluent 1.68 m^3/ton of barley. By spraying, the effluent clearly was lower; it was between 1.68 and 0 m^3/ton of barley. Use of the first steep water for spraying (method D) reduced the effluent waste to 0.13 m^3/ton without any disadvantages in germination. The malting and rootlet

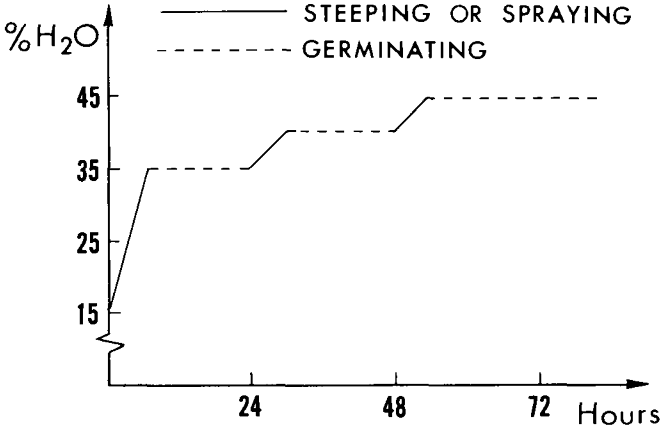

Fig. 1. Steeping time and moisture content of the barley.

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[1] Presented at the 42nd Annual Meeting, Milwaukee, May 1976.

[2] Editorial clarification: "Analytical values" basically are EBC as obtained by the methods of Analytica-EBC, 3rd ed., Schweizer Brauerei-Rundschau, CH-8047, Zurich, Switzerland (1975). Where "ton" is used, it is metric, *i.e.*, 1000 kg (2204.6 lb).

[3] G. Schumann, private communication.

TABLE I
Influence of Steeping Process and Amount of Water on the Malt Quality

Method Number	1	2	3	4	5
First Steep	flushing	flushing	flushing	flushing	spraying
Second Steep	flushing	flushing	spraying	spraying	spraying
Third Steep	flushing	spraying	spraying	spraying	spraying
Water usage, m^3/ton[a]	2.40	1.67	1.02	0.75	0.72
Effluent, m^3/ton[a]	1.68	0.95	0.3	0.03	0.00
Recycling	...	...	...	yes	...
Malting loss, % dry matter	7.8	8.7	8.9	8.3	8.0
Root loss, % dry matter	3.6	4.5	4.7	4.6	4.9
Moisture, %	3.8	3.6	3.9	3.7	3.9
Fine extract, %	81.4	81.3	81.5	81.4	81.6
Coarse/fine extract difference	2.0	2.2	2.5	2.4	2.5
pH	5.80	5.82	5.87	5.89	5.93
Color, EBC	3.5	3.7	3.9	4.3	4.3
Total protein, %	10.5	10.6	10.4	10.2	10.4
Soluble nitrogen, mg/100 g malt	750	735	740	737	736
Kolbach index, %	44.7	43.5	44.5	45.3	44.2
Viscosity, cP	1.558	1.554	1.558	1.576	1.568
α-amylase, DU	64	64	69	67	69
Diastatic power, °WK[b]	251	256	251	231	237

[a] Metric ton = 2204.6 lb.
[b] WK = Windisch-Kolbach (0.3 WK + 4 = °Lintner, approx.).

TABLE II
Influence of Water Hardness on Malt Quality

Hardness, °dH	Flushing 45[a]	Spraying 45[a]	Spraying 0
pH	5.87	6.00	5.99
Color, EBC	2.9	3.5	3.5
Buffering, ml	10.36	10.71	10.85

[a] 45 dH = 801 mg/l. as $CaCO_3$.

loss were not perceptibly influenced through the different steeping processes. There were practically no differences in malt quality, with the exception of the pH and color.

With decreasing water usage, there was a distinct increase in pH and color of the Congress wort. The pH increase may be traced back to a reduction of the washing-out of buffering materials during steeping. This is in agreement with Hopkins and Kelly (9), who found that the pH falls about 0.4 to 0.6 units during steeping.

Color of the Congress wort increased with the reduced washing-out of color substances and polyphenols. Stage (19) also found a higher pH and color in spray steeping trials.

Influence of Water Hardness on Malt Quality by Spray Steeping

During spray steeping, with no effluent, all water minerals remain on or in the malt; accordingly, whether or not pH, color, and buffering are influenced by this procedure was examined. Steeping was conducted in water with a permanent hardness of 14° dH (249 mg/l.) and a temporary hardness of 31° dH (552 mg/l.), and compared with distilled steep water. The results, given in Table II, show that the degree of hardness had no influence on pH, color, and buffering of the Congress wort.

Influence of Spray Steeping on Malt and Beer Quality (Semicommercial Malting)

Comparisons with conventional steeping and spraying in the germination compartment were done in a semicommercial plant. The steeping time lasted 48 hr at 14°C and the water usage, with two changes of water, was 5 m^3/ton of malt. Water addition for the spray steeping was made every 8 to 12 hr if the surface of the barley was dry. Each time only as much water was sprayed on as the barley could absorb. Water usage was 0.77 m^3/ton of malt. The steeping and germinating time was 7 days; the germinating temperature was 14°C.

During conventional steeping, 105 mg polyphenols/1 kg barley was washed out (Table III), which corresponds to about 14 mg/l. in the Congress wort. Nevertheless, there was practically no difference in the wort. Obviously there is such a great surplus of soluble polyphenols in malt that less extraction during steeping made no difference. With the exception of the earlier discussed differences in color, buffering, and pH, the effluent-free spray steeping method had no influence on the malt analysis. This closely agrees with the results of Reynolds *et al.* (17) and Voborsky (20).

In the brewing process, malts of the spray steeping methods gave, on the average, a slight delay in lautering. No reason could be found for it. In commercial trials, however, Esser and Zaake[4] found no differences in lautering. The fermentation time in all trials with the wort from spray steeped malt was significantly faster. The average time was reduced about 2 days. According to Holes and Holesova (8), MacWilliam *et al.* (16), and Button and Hudson (2), growth substances which stimulate yeast production and fermentation are contained in effluent steep water. These growth materials obviously remain in the malt during the spray steeping process and could lead to a faster fermenting wort. There were no differences in secondary fermentation or in filtration of the beer. The wort analysis corresponds essentially to the malt analysis. The pH of the wort from the spray steeped malt is about 0.19 units higher and the color about 1.6 EBC units higher than the control standard. The bitter substances are about 7% higher in the beer because of the higher pH in the trial worts. For the same reason, insignificant differences in total nitrogen and α-amino acids were found. Also, there were no important differences in polyphenols in the wort or anthocyanogens in the beer.

The beer analysis also showed no important differences. The big differences in pH and color shown in the malt and wort analysis were reduced during beer fermentation and storage. Nevertheless, the color is 0.5 units and the pH is 0.07 units higher than the control standard. All other analytical data vary only within the limits of error. While Kieninger and Graf (10) found a significant increase in the content of polyphenols and anthocyanogens in beer in their

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[4] D. Esser and G. Zaake. Untersuch. d. techn. wiss. Ausschuss. d. VLB (in press).

TABLE III
Influence of Spray Steeping on Malt and Beer Quality

	Conventional Steeping	Spray Steeping
Water usage, m^3/ton	5.00	0.77
Polyphenols washed out, mg/kg	104.6	...
Malting loss, % dry matter	7.6	7.4
Root loss, % dry matter	3.5	3.2
Malt analysis		
Fine extract, %	81.1	81.0
Coarse/fine extract difference, EBC	2.7	2.7
Color, EBC	2.7	3.8
pH	5.81	5.97
Soluble nitrogen, mg/100 g malt	699	674
Kolbach index, %	42.5	40.9
Viscosity, cP	1.63	1.60
Buffering, ml	10.37	10.78
Polyphenols, mg/kg	60	61
α-amylase, DU	67	66
Diastatic power, °WK	237	237
Wort analysis		
Gravity, % Plato	12.03	11.96
pH	5.39	5.58
Color, EBC	9.1	10.7
Total nitrogen, mg/l.	1136	1078
$MgSO_4$-N, mg/l.	198	203
Koag.-N, mg/l.	27	24
α-amino nitrogen, mg/l.	235	213
Polyphenols, mg/l.	259	267
Anthocyanogens, mg/l.	116	114
Bitter units, mg/l.	46.5	49.9
Viscosity, cP	2.19	2.11
Lautering time, min	179	202
Brewhouse yield, %	75.8	75.6
Fermentation time, days	8.5	6.3
Beer analysis		
Original gravity, % Plato	12.25	12.20
Final deg. of attenuation, %	79.8	79.3
Actual deg. of attenuation, %	77.2	78.4
Color, EBC	7.4	7.9
pH	4.49	4.56
Buffering, ml	19.89	20.21
Total nitrogen, mg/l.	916	853
$MgSO_4$-N, mg/l.	158	159
Koag.-N, mg/l.	18	20
Bitter units, mg/l.	34,8	35,6
Foam, sec	124	123
Polyphenols, mg/l.	236	225
Anthocyanogens, mg/l.	79	79
Chill haze, EBC	4.4	4.7

TABLE IV
Beer Taste

No. of tasters: 90

1. Taste test with fresh beer

	flushing	spraying
Preferred	48	42

2. Taste test after 6 weeks at 25° C

	flushing	spraying
Preferred	42	48

experiments, no differences were found in this study. A very important quality criterion is the taste of the beer.

All resulting beers were tasted in a two-glass test with assignment of the third glass immediately after bottling and after a 6-week storage period at 25° C. The results of this evaluation are shown in Table IV. The results show clearly that the effluent-free steeping process resulted in no negative influence on the beer taste.

CONCLUSION

A reduction of effluent during steeping of barley, or a recycling of the steep water in the germinating compartment, had no influence on malt and beer quality, with the exception of higher color and pH. A significant advantage was in reduction of the fermentation time required.

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