VIII.—*On the Steeping of Barley.*

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1. IN the course of the processes which have for their object the preparation of malt from barley, the grain has to undergo a more or less prolonged immersion in water. Various kinds of natural water, some of them of scarcely compatible character, are highly esteemed for the purpose of this steeping. We have not, however, been able to

find any published statements * of a detailed description as to the action of water upon barley; and it appeared to us desirable to make an experimental outline, at least, of this undoubtedly complicated phenomenon. Our results are contained in the following paragraphs.

2. The barley we employed throughout our investigations was a fine sample of "chevalier," grown on limestone soil. Its analysis furnished the percentages recorded below—

Moisture	13·95
Nitrogen	1·87
Ash	2·23

3. The apparatus we employed consisted of a series of glazed cylindrical earthen pots, which were placed on a platform in a tank of water kept constantly running, and supplied from the main. Into each pot we introduced 300 grams of barley and 400 cc. of water, or some aqueous solution under trial, and the whole was covered with a glass plate. Each set of experiments, hereafter referred to in the tables, was made at one time, and under the same conditions. Temperatures were taken at noon by direct observation, and at midnight by an automatic recording thermometer; the mean of these temperatures is stated in each case.

4. It is obvious that, in working with a number of individual grains of barley, there may have been some whose outer coatings were injured, and which may have yielded extract with more than average rapidity; this is a source of error to which we are undoubtedly, though—as we believe, from actual inspection of many of the grains—but very little exposed. Moreover, to destroy other small errors, we always employed 300 grams of barley—a by no means inconsiderable weight; and for the sake of obtaining larger results, we prolonged the operation of steeping to 72 hours.

I. *Calcic Carbonate.*

5. A solution of calcic carbonate was made by passing purified carbonic dioxide through distilled water, in which well washed calcic carbonate was suspended. The filtered (saturated) solution contained ·0896 per cent. of carbonate.

* Messrs. Lawes and Gilbert, in a Parliamentary Report (1866, Reprint, 1868) "On the Relative Values of Unmalted and Malted Barley," drew attention to the loss in steeping of "a certain amount of solid matter, which consisted of saccharine, nitrogenous, and mineral substances" (p. 22). They also found (p. 65) that the barley imparted 391·66 grains per gallon of solid matter (containing 8·62 grains of nitrogen) to the water they had occasion to employ. Our thanks are due to Dr. Gilbert for a copy of this Report.

Average temperature, 4·8° C.

TABLE I.

Experi- ment.	Carbonate in 100 c.c.	Residue from 100 c.c.	Ash from 100 c.c.	Extract in 100 c.c.	Nitrogen from 150 c.c.
I	0·0896	0·4817	0·3017	0·1800	0·00546
II	0·0672	0·4670	0·2870	0·1800	0·00742
III	0·0448	0·4582	0·2830	0·1752	0·00770
IV	0·0224	0·4440	0·2752	0·1688	0·00973
V	0·0000*	0·4015	0·2540	0·1475	0·00952

According to these numbers, as we diminish the amount of carbonate in the water, so the extract decreases. The nitrogenous constituents of the extract simultaneously increase up to Expt. IV; but distilled water extracts distinctly less of them than the ·0224 solution of calcic carbonate.

II. *Calcic Sulphate.*

6. This salt was prepared by bringing well washed chalk in contact with very dilute sulphuric acid, stirring frequently during three weeks, and filtering the neutral liquid.

Average temperature, 11·0°.

TABLE II.

Experi- ment.	Calcic sulphate in 100 c.c.	Residue from 100 c.c.	Ash from 100 c.c.	Extract in 100 c.c.	Nitrogen from 150 c.c.
I	0·2210	0·7240	0·4440	0·2800	0·00546
II	0·1657	0·7470	0·4296	0·3174	0·00616
III	0·1105	0·6000	0·3440	0·2560	0·00532
IV	0·0552	0·5480	0·3400	0·2080	0·00560
V	0·0000	0·5110	0·2760	0·2350	0·00716

Here also we notice that the extract decreases, *pari passu*, with the calcic sulphate from Expt. II to Expt. IV. The nitrogen and extract results are greatest of all at Expt. II. At Expt. V, as in the case of the carbonate, we get a disproportionate increase of nitrogen in the extract, but, in addition, a greater total extract. The total extract or nitrogen per unit of calcic salts is much greater with calcic sulphate than with carbonate.

* Distilled water alone was here used.

Burton Water.

7. Through the good offices of a friend, we were able to procure some water which is much used and held in great esteem for steeping purposes in Burton. The water is actually drawn at Lichfield, and our sample was turbid. In the following determinations we have compared it with a water analysed by the Rivers Commission (*Report*, p. 105), and described as being derived from a deep well in the new red sandstone at Lichfield. The numbers refer to parts per 100,000, excepting those relating to dissolved gases, which represent volumes per cent.

TABLE III.

		Rivers Commission.
Total solid matter.....	32·440	32·060
Organic carbon	—	0·163
Organic nitrogen	—	0·038
Ammonia	—	0·003
Nitric nitrogen	0·393	0·489
Silica	0·656	—
Magnesia (MgO)	1·412	—
Lime (CaO)	10·034	—
Sulphate (SO ₄).....	4·450	—
Chlorine.....	1·950	2·200
Hardness (temporary)..	7·070	9·300
„ (permanent) ..	11·100	9·000
„ (total)	18·700	18·300

Dissolved Gases.

Carbonic dioxide	3·0211	—
Nitrogen	3·4747	—
Oxygen	3·1080	—

The Rivers Commission considered their sample to have been polluted, as was doubtless the case with our own.

The measured effects of steeping are as follows:—

TABLE IV.

Experiment.	Residue from 100 c.c.	Ash from 100 c.c.	Extract from 100 c.c.	Nitrogen from 150 c.c.
I. Burton water	0·4540	0·2427	0·2113	0·00525
II. Half Burton water ..	0·4100	0·2207	0·1893	lost
III. Distilled water	0·4132	0·2230	0·1902	0·00630

Mean temperature 47°.

Here again the extract decreases as we approach to distilled water.

8. On account of the great importance of this particular water, we prepared two waters bearing a partial resemblance to it, and tried with them some steeping experiments. We shall call these liquids "Factitious Water A" and "Factitious Water B."

Factitious Water A.

Assuming the whole of the sulphate in the Burton product to be calcic, and all the chlorine to be sodic, we compounded this Water A, which was a solution of sulphate and chloride in distilled water, in the same proportions as we had found in the Burton supply.

Mean temperature, 6·9°.

TABLE V.

Experiment.	Residue from 100 c.c.	Ash from 100 c.c.	Extract from 100 c.c.	Nitrogen from 150 c.c.
I. Water A	0·4382	0·2430	0·1952	0·00448
II. Half water A	0·4734	0·2450	0·2284	0·00651
III. Distilled water	0·4132	0·2112	0·2020	0·00483

Thus, Water A gives rise on the whole to more extract and less nitrogen than the Burton sample. Water A and distilled water have about the same effect.

Factitious Water B.

9. Assuming the temporary hardness to be due to calcic carbonate, and the chlorine to be wholly sodic, we prepared this water so as to be a solution in these respects of the same composition as our Burton sample.

[The carbonate had been previously dissolved in carbonic water.]

Mean temperature 8·0°.

TABLE VI.

Experiment.	Residue from 100 c.c.	Ash from 100 c.c.	Extract from 100 c.c.	Nitrogen from 150 c.c.
I. Water B	0·4528	0·2372	0·2156	0·00488
II. Half water B	0·4630	0·2350	0·2280	0·00600
III. Distilled water.....	0·4334	0·2274	0·2060	0·00588

Like Water A, this water takes up most extract and most nitrogen at the half dilution, and in nearly the same absolute amount. Water B takes up less nitrogen than distilled water.

Supplementary Experiments.

10. We took occasion to examine several of the liquids in which we had steeped barley.

All the solutions and ashes contained phosphates. In the gypsum solution there was an alkaline sulphate. The carbonate solution was slightly acid, and gave a precipitate on boiling; the filtrate was not acid, and was free from phosphate.

11. The reaction of water in which barley has been steeped is slightly acid, and its colour orange, or deep orange-yellow. Such water gives a white precipitate with hydric metaphosphate* in the cold, and the filtrate yields a further precipitate on boiling.

Water containing calcic sulphate was found to have taken up less colouring water than distilled water, and to be lighter when more calcic sulphate was present. One of the gypsum water extracts, when heated to boiling, gave far less precipitate than the aqueous extract. It furnished no precipitate in the cold with hydric metaphosphate.

12. Although the amount of organic constituents extracted from barley is small, seldom exceeding four-tenths per cent., we cannot consider it unimportant. In the chemistry of minute quantities we repeatedly find vast qualitative effects arising from the presence of small masses, and depending sometimes for their very occurrence on the condition that the masses are small. May not the absence, at a critical time in the life of the sprouting plant, of a little or all of its most soluble albuminoid, materially affect the quality of the resulting malt; when even so apparently indifferent a circumstance as the mode of supplying air to the plant produces a marked alteration of character?

Inferences and Remarks.

It is obvious from the experiments recorded in (11) that water in which barley has been steeped contains at least two albuminoid bodies, one of which is thrown down by metaphosphate in the cold, the other on boiling. The former of these can be wholly kept back within the grain by the action of a gypsum solution, and probably, but with rather less efficiency, by a chalk solution.

13. The results given in the Tables show that one general effect of a calcic solution is to keep back nitrogenous matter within the grain;

* This reagent, which has been for several years employed by one of us as an extremely delicate reagent for albumin, is prepared as follows. A quantity of sodic metaphosphate (Maddrell's) is covered with strongly acetified water, set aside, and occasionally shaken. The clear liquid, which must always be kept over the undissolved sodic salt, constitutes the reagent. The metaphosphate has the great advantage over the nitrate of not decomposing albumin when boiled therewith.

but the strongest solutions ever likely to be employed in malting are far from entirely preventing the escape of nitrogenous matter.

If we glance also at the "nitrogen" as compared with the "extracts," we cannot fail to perceive that the greater part of the extracts is made up of non-albuminous bodies. In most cases, the stronger the steep-water is in saline constituents, the greater is the amount of extract withdrawn, and the less the amount of albuminoid matter allowed to escape.

14. In comparing Table VI with Table V, it will be found that the mineral constituents in Water A probably counterbalance each other's effects, so that, on the whole, Water A acts like distilled water. Water B very closely resembles Water A as to extract; but when compared with distilled water, it is seen to take out less nitrogen.

If we have regard to temperature, it is probable that the Burton water takes out more nitrogen than, and at least as much extract as, either gypsum or chalk solution, or waters resembling the Burton sample in (1), gypsum + common salt, or (2), chalk + common salt. The special esteem in which the Burton sample is held may therefore be due to its nitrate, which is well known to have a highly stimulant action in the germinating of malt—a process which demands much oxygen.

15. The practical value of our experiments will depend very much upon the view taken by maltsters as to the propriety of locking up, as far as possible, both the non-albuminous and albuminous matters of the grain. Opinions as to the employment of hard or soft waters are at present very much divided. For our own part, we lean to the belief that the healthy germination of the seed will be best promoted by keeping within it as much as possible of its natural constituents, as is done in ordinary processes of agricultural growth. We have, however, shown that the usually available reagents for this purpose, if employed in the concentrated form, take out more extract; if in the diluted form, more albumin. The proper compromise, then, will be to select a reagent of medium strength; and the best at present known to us is a gypsum solution containing about one-tenth per cent. It would be easy, and probably advantageous, to add to this such a proportion of calcic nitrate as would correspond to a few tenths per 100,000 of nitric nitrogen. Finally, the question naturally occurs, Why not use sufficient water just to saturate the grain, and no more? If this plan were adopted (and we are unaware of any practical difficulties in the way), the softest natural water might be employed with success, and not a trace of its constituents would be lost, as in the best existing practice, to the germinating grain.