HGCA

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MALTING AND BREWING TRIALS OF NEW BARLEY VARIETIES - 1995/97

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MALTING AND BREWING TRIALS OF NEW BARLEY VARIETIES - 1995/97

by

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ABSTRACT

Aims: The aim of this project was to provide pilot scale malting and brewing data on new barley varieties. The data was then used by the Institute of Brewing (IOB) to assess the varieties for Provisional or Full Approval as a recommended variety for malting, brewing or distilling.

The varieties selected for trials were those put forward by the English Working Party of the IOB and the final Approval (or otherwise) was also determined by the same institute. BRI ran the trials but did not assign final approval, nevertheless the outcome of these trials is provided below.

BRI carried out micromalting (350g), pilot malting (50kg) and, subsequently, pilot-scale brewing (100l) on the new barley varieties.

Conclusions: Barleys Selected for Trials with outcome of approval procedure.

1995 Crop, Spring Barleys:

Trial: none
Site Control: none

Winter Barleys:

Trial:	Gleam	Approved
	Prelude	Not Approved
	Regina	Approved

Site Control: Halcyon

1996 Crop, Spring Barleys:

Trial: Landlord	Approved

Site Control: Chariot

Winter Barleys:

Trial: Rifle	Approved

Control: Halcyon

1997 Crop

No barleys were put forward for trials in this year.

SUMMARY OF PROJECT

The 1995 Crop

The barleys

Barleys selected for pilot-malting trials comprised the three winter varieties Gleam, Prelude and Regina, with Halcyon as the site control. On receipt, the barleys were screened and analysed [See Results Table IA].

All the barleys were suitable for malting. The Regina was a significantly larger grain than either Gleam or Prelude, though all were larger than the control as reflected by thousand corn weight and sieve analysis. There was some variation in Total Nitrogen Content, Gleam being significantly higher in nitrogen than the others.

Malting

Micromalting was carried out according to the methods described in the methods section. Malts were prepared with and without GA for each steeping procedure and the results are shown in Results Tables II A-D.

The Halcyon control exhibited low extract, SNR and FAN values when GA was not applied but all gave acceptable values when this growth regulator was added.

None of the trial varieties produced a significantly greater extract than the Halcyon control and, indeed, the extract from the Gleam malt was significantly lower than the control and the other varieties under test. This may be related to the higher nitrogen content of the Gleam barley.

Protein modification, as assessed by SNR, was better in the trial malts than the control though all showed positive responses to the use of GA. Prelude gave the highest SNR (50%) and lowest viscosity (1.45mPas) under the aerobic steeping regime with GA. Prelude also exhibited the highest malt friability values throughout and Regina the lowest.

Table IIIA (See Results) shows the analytical values for the four lager malts produced in the Pilot Maltings. The same process conditions were used for all the barleys with GA being sprayed onto the grain at cast. Halcyon, Prelude and Regina received 0.1ppm (0.1mg GA/kg raw barley) whereas Gleam needed 0.2ppm GA to ensure adequate extract development during malting. The HWE_7 values were all within specification but in no case did the trial malts produce a higher extract that the control. Malt SNR values, however, were all higher in the trial barleys than the control. All the malts produced in the pilot maltings were either within or very close to the target specification required for brewing.

Brewing

All four pilot malts were brewed as premium lagers using the procedure described in Section 2.4.

(i) Brewhouse Performance

Wort separation was good for all of the pilot malts. Only the halcyon control showed slight break up of the husk bed but this was very minor and had little influence on the results. All the malts generated some 98 litres in 80 minutes, this is the normal performance of this pilot brewery.

(ii) Fermentation Performance

The original gravity of the worts used was 1.0443 +/- 0.0002. All of the experimental malts showed very slightly better attenuation then the control but the differences could not be seen as significant.

(iii) Bottled Beer Analysis.

The analytical parameters of these beers are shown in Tables IVA and IVB. There were no significant differences between any of the beers. During tasting the beer made from Halcyon and Regina did not show any major flavour defects. Beer made from Glam was identified as possessing an acetaldehyde note. The beer made from Prelude showed a range of negative flavours including grainy, cabbage and bready.

The 1996 Crop

The barleys

Barleys selected for pilot-malting trials comprised the winter variety Rifle and the spring variety Landlord (Halcyon and Chariot respectively were used as site controls). On receipt, the barleys were screened and analysed [See Results Table IB].

The germination characteristics as assessed by standard IOB methods showed that all the barleys were suitable for malting. The Landlord sample had a higher nitrogen content and smaller corn size than its site control. Both the control and trial winter samples had a low nitrogen content (approx. 1.3%) and there was a big difference in corn size - the Rifle was a bold corn, having a TCW of over 40g with more than 80% of the sample being retained on the 2.8mm sieve.

Malting

Prior to pilot scale trials, micromalting was carried out according to the methods described. Malts were prepared with and without GA and the results are shown in Results Table II E and F.

The spring barleys were steeped to a moisture, 24h after casting, of approximately 49%. This resulted in high friability and low viscosity through out. Fermentability in Table II was carried out on the unboiled lab extract (IOB Method 2.15). This gives results about 10 units higher than that obtained on boiled worts (see results of pilot malts). Extracts for the Chariot control were acceptable at about 310 l°/kg, and these were not significantly affected when GA was applied. TSN levels were increased after application of GA, SNR increasing from 34 to 39%. Extract potential of the Landlord was not increased by GA, and SNR was only slightly affected (rising from 42 to 45%). The Landlord malts exhibited lower extracts than the Chariot control although nitrogen modification was better.

The winter barleys were steeped to a cast moisture of about 46%. The extracts produced were high as a result of the low barley TN (Ca. 1.3%). Even so, Rifle produced a significantly higher extract than the Halcyon control, especially when GA

was not used, and this was reflected in the Friability results. TSN values for Rifle remained low, and even when GA was employed SNR only increased from 35 to 37% compared to the increase exhibited by Halcyon of 36 to 45%.

Table IIIB (See Results) shows the analytical values for the malts produced in the Pilot Maltings

The two spring barleys were malted to produce premium lager malts, as is normal for these trials. However the low total nitrogen of the winter barleys precluded their use for the production of lager malt, therefore it was decided to produce malts to a pale ale specification. The lager malts were manufactured without the use of processing aids, whilst the ale malts were treated with GA at 0.1ppm applied at casting. The processing conditions used are summarised in Appendix B.

1. Spring Barleys - Premium Lager Malt

The analysis of the Chariot and Landlord malts made on the Pilot Maltings is shown in Results Table IIIB. Both barleys were steeped to a cast moisture of 45%. Satisfactory extract was achieved by Chariot, but the Landlord malt did not reach the specification required. This corroborates the result from the 350g micromalting where the extract potential of Landlord was lower than that of the site control. SNR values for both malts were below target values - this could have been rectified had GA been employed at casting.

2. Winter Barleys - Pale Ale Malt

The analysis of the winter barley malts is shown in Table IIIC. Both the control and Rifle trial barley were treated with 0.1ppm GA at cast . Even so, TSN and FAN values were rather low, while extracts were above the target specification in both cases. The Rifle malt appears to have better carbohydrate and cell wall modification (viscosity was lower) than the Halcyon control. This is not necessarily a bad thing since the processor is looking to maximise extract, however, protein modification was poorer than the control. Some caution should be expressed here because of the very low nitrogen content of

these samples. The low response to GA exhibited by the rifle on the pilot plant was also observed during micromalting at 350g.

Brewing

Lager Brews

Single brews were made on the 100 litre scale using the malts produced in the 50kg maltings (Chariot control and Landlord trial).

(i) Brewhouse Performance

Wort run-off was adequate for both malts, but raking in the lauter tun was required for the Chariot control in order to lower the differential pressure across the bed. This was not required with the Landlord malt. Sweet wort clarity in both cases was also good, as was the pitching wort clarity. No difficulties were observed either in the kettle or during trub separation in the whirlpool. Brewery extract for the control was higher than the trial malt, reflecting the HWE7 malt analysis.

(ii) Fermentation Performance

Original gravity in both lager pitching worts was the same at 1044.5. The Chariot control attenuated through 37.5°G compared with the Landlord trial which attenuated through 38.3°G. There is no significant difference between these two results, with both worts being very fermentable.

(iii) Bottled Beer Analysis

The analysis for the two premium lager beers produced from the Chariot and Landlord malts is shown in Table IVC. There are no significant differences between the two beers, either in analytical parameters or in the results of flavour profile tasting. In particular colour, bitterness and foam characteristics were within specification for this product.

Best Bitter Brews:

Single brews were made on the 100 litre scale using malts produced on the 50kg maltings (Halcyon control and Rifle trial).

(i) Brewhouse Performance

The control run-off was poorer than the Rifle trial malt which required no special handling in the lauter tun. In contrast the Halcyon control required raking and underletting to achieve the necessary flow rate. Sweet wort clarity was described as poor and that for the Rifle as fair. However after boiling, trub separation in the whirlpool was satisfactory for Halcyon, but poor for Rifle. The brewery extract obtained from Rifle was significantly higher (10%) than that achieved by the Halcyon malt, reflecting the HWE values obtained in malt analysis.

(ii) Fermentation Performance

Both worts were pitched at 1038° and the attenuation was identical (32°G) for both trials. This is normal for pale ale malts and corroborates the lower fermentabilities characteristically seen with ale malts .

(iii) Bottled Beer Analysis

The analysis of the best bitters is shown in Table IVD. Although colours were below the BRFI Best Bitter spec., there was no signification between them. There was some indication that the potential for fermentation was greater for Rifle (see lower attenuation limit), and foam stability as measured by NIBEM was better for the trial. Both beers exhibited very low TSN and FAN - this is probably due to the low TN values seen in both barleys prior to malting. Ethanol levels were identical.

REFERENCES

1. The Institute of Brewing, *Recommended Methods of Analysis* 1991.

2. KELLY G.R: *Brew. Distill. Int.*, Dec 1987, **17(12)**, 40-41.

Conclusions

Gleam, Prelude and Regina all produced malts of a satisfactory quality for brewing and gave no problems during brewhouse processing but were found to be no better than the established variety Halcyon. From harvest 1995 the samples supplied to BRFI each needed the addition of GA, Gleam needing a higher level to achieve an acceptable analysis.

Compared to Chariot, Landlord exhibited low extract potential but better protein modification. Both barleys malted satisfactorily and gave no problems through the pilot brewery.

Rifle produced higher extracts than the control, but there was clear indication that TSN and SNR values were lower. These samples had a very low protein content, thus extracts were high and TSN / FAN values low. In the pilot brewery no significant problems were seen with the trial wort run-off or clarity. However trub separation in the whirlpool was poorer than observed for the control. Fermentation characteristics and final beer quality were all satisfactory.

METHODS

Barleys

All barleys were supplied by ADAS and grown in Berkshire.

Malting Protocols

When a barley sample was received, it was submitted for rapid moisture analysis using an infra-red balance. If necessary the sample was dried to *ca* 12% moisture and then submitted for sieve analysis. Fractions greater than 2.2mm were combined and analysed for moisture, total nitrogen, thousand corn weight and germination properties according to the Recommended Methods of the IOB[1].

GERMINATION TESTS

Germinative Capacity (72h in 0.75%v/v H_2O_2; 16°C).

Any corns living will be stimulated to germinate in the presence of 0.75% H_2O_2 (even the dormant ones). For malting purposes germinative capacity should be as near to 100% as possible.

Germinative Energy (4ml plate; 72h; 16°C)

This gives an indication of the number of corns liable to germinate under normal malting conditions. The difference between the germinative capacity and the germinative energy is a measure of the dormancy. Provided that the barley sample has a germinative energy greater than or equal to 95% then further assessment will proceed.

Water Sensitivity: (8ml plate; 72h; 16°C)

This gives a measure of the susceptibility of embryo development to excess water.

ROUTINE MICROMALTING ASSESSMENT

The 350g Micromalting facility is used for this purpose.

Two standard steeping procedures were employed:

(i) 8h wet/16h air rest/24h wet.

(ii) 7h wet/17h air rest/7h wet/17h air rest/3h wet.

Steep schedule (i) minimized air rest time and maximised immersion time whilst schedule (ii) did the opposite. Both were designed to give a cast moisture of 43-45%. Some idea of the "maltability" of the sample can be obtained from malt produced under these conditions e.g. water sensitive samples may not fare well after steeping by schedule (i).

Samples were processed in duplicate, one set being sprayed with GA at casting (normal rate of addition: 0.2ppm in 7ml water, based on 350g barley weight), the other with an equivalent volume of water.

A standard germination period of 4 days at 16°C followed the steeping. At the end of this stage, the green malt was dried on shallow trays in a forced draught oven for 24h (8h @ 45°C; 16h @ 65°C).

The finished malts were then analyzed for a range of parameters[1] including extract, nitrogen, viscosity, fermentability and friability.

PILOT MALTING

Information obtained from micromalting on the 350g scale was then be used to devise malting schedules for production of pilot scale batches using the BRFI 50kg malting plant[2]. The process conditions employed are shown in Appendix A.

Analysis of barley, malt, wort and beer

These measurements were all made using IOB Recommended Methods[1]. A table describing the analyses employed to assess malt quality and a short summary of their significance is shown in Appendix C.

Brewing

This was carried out in the 100l Pilot Brewery at BRFI. The pilot malts were used to brew BRI Premium lagers (OG 1044) according to standard BRI protocols.

The brewhouse comprised a modern system incorporating a stirred mashing-in vessel; lauter-tun; kettle; whirlpool and wort receiver. A temperature programmed mash, was carried out in the mashing-in vessel. The mash was held at 64°C for 1h and then the temperature was ramped to 78°C in 14 mins, followed by transfer to the lauter tun for wort separation. Wort run-off took place over 90 mins, the wort being collected in the kettle. The wort was boiled for a total of 1.5h with 15.5g Hop CO_2N and a further 29g of Saaz pellets was added 10 minutes before the end of the boil. The wort was then transferred to the whirlpool for wort clarification and diluted to standard gravity in the wort receiver. The wort was cooled to 12°C and 60l transferred to a cylindro-conical fermenter where it was pitched with yeast and fermented for 6 days at 12°C. After primary fermentation, the green beer was warm conditioned for 3 days at 13°C and then chilled to 0°C.

RESULTS

TABLE I A: BARLEY ANALYSES 1995 CROP

	HALCYON	GLEAM	PRELUDE	REGINA
ANALYSIS				
Moisture (%)	11.2	11.9	11.4	11.5
TN (%)	1.58	1.68	1.58	1.63
SIEVE (MM)				
> 2.8	24.5	53.9	42.1	69.7
2.5 - 2.8	49.2	31.0	39.9	19.7
2.2 - 2.5	20.8	9.5	13.8	7.2
< 2.2	5.5	5.6	4.2	3.4
GERMINATION TESTS (%)				
Capacity	98	96	97	99
Energy	98	96	98	99
Water Sensitivity	62	42	65	70
Thousand Corn weight (TCWg)	34.2	37.6	36.0	43.7

TABLE I B: BARLEY ANALYSES 1996 CROP

	CHARIOT	LANDLORD	HALCYON	RIFLE
ANALYSIS				
H_2O (%)	12.2	11.6	12.2	12.2
TN (%)	1.68	1.75	1.36	1.31
SIEVE (MM)				
> 2.8	55.9	31.8	35.7	81.9
2.5 - 2.8	26.7	32.2	52.2	13.7
2.2 - 2.5	12.9	24.5	9.4	2.5
< 2.2	4.5	11.5	2.7	1.9
GERMINATION TESTS (%)				
Capacity	99	97	98	97
Energy	96	96	98	96
Water Sensitivity	41	26	62	77
Thousand Corn weight (TCWg)	30.9	29.6	35.1	40.5

TABLE IIA: MICROMALTING (350G SCALE) - MALT ANALYSES

HALCYON

STEEP	GA	HWE_2 (l°/kg)	HWE_7 (l°/kg)	C/F (l°/kg)	TSN (%)	TN (%)	SNR (%)	FAN (mg/l)	FERM (%)	VISC. (mPas)	FRIAB. (%)
8/16/24	-	309	303	6	0.46	1.52	30	85	72	1.72	84
	+	310	310	0	0.65	1.53	42	132	74	1.54	92
7/17/7/17/1	-	308	305	3	0.48	1.55	31	84	73	1.64	88
	+	313	313	0	0.64	1.49	43	149	75	1.52	96

TABLE IIB: MICROMALTING (350G SCALE) - MALT ANALYSES

GLEAM

STEEP	GA	HWE_2 (l°/kg)	HWE_7 (l°/kg)	C/F (l°/kg)	TSN (%)	TN (%)	SNR (%)	FAN (mg/l)	FERM (%)	VISC. (mPas)	FRIAB. (%)
8/16/24	-	304	301	3	0.54	1.57	34	100	72	1.72	86
	+	308	306	2	0.73	1.59	46	150	75	1.56	94
7/17/7/17/1	-	304	301	3	0.55	1.58	35	116	73	1.56	88
	+	307	307	0	0.71	1.59	45	134	76	1.55	95

TABLE IIC: MICROMALTING (350G SCALE) - MALT ANALYSES

PRELUDE

STEEP	GA	HWE_2 (l°/kg)	HWE_7 (l°/kg)	C/F (l°/kg)	TSN (%)	TN (%)	SNR (%)	FAN (mg/l)	FERM (%)	VISC. (mPas)	FRIAB. (%)
8/16/24	-	309	305	4	0.57	1.53	37	118	74	1.49	93
	+	312	312	0	0.77	1.55	50	179	76	1.46	97
7/17/7/17/1		305	304	1	0.59	1.56	38	129	75	1.48	93
	+	309	309	0	0.75	1.54	49	178	77	1.45	97

TABLE IID: MICROMALTING (350G SCALE) - MALT ANALYSES

REGINA

STEEP	GA	HWE_2 (l°/kg)	HWE_7 (l°/kg)	C/F (l°/kg)	TSN (%)	TN (%)	SNR (%)	FAN (mg/l)	FERM (%)	VISC. (mPas)	FRIAB. (%)
8/16/24	-	309	305	4	0.53	1.57	34	107	73	1.55	78
	+	313	312	1	0.75	1.57	48	177	74	1.50	89
7/17/7/17/1	-	307	305	2	0.53	1.56	34	109	74	1.52	87
	+	312	310	2	0.73	1.57	46	179	76	1.48	93

TABLE IIE : MICROMALTING (350G SCALE) - MALT ANALYSES (SPRINGS)

Control: Chariot

STEEP	VAR.	GA	HWE_2 (l°/kg)	HWE_7 (l°/kg)	C/F (l°/kg)	TSN (%)	TN (%)	SNR (%)	FERM (%)	VISC. (mPas)	FRIAB. (%)
7/17/7/17/1	C	-	311	309	2	0.56	1.63	34	87	1.50	94
	C	+	311	310	1	0.67	1.70	39	87	1.48	96
Trial: Landlord											
7/17/7/17/1	L	-	306	306	0	0.74	1.76	42	86	1.45	95
	L	+	307	305	2	0.79	1.75	45	86	1.46	95

TABLE IIF: MICROMALTING (350G SCALE) - MALT ANALYSES (WINTERS)

Control: Halcyon

STEEP	VAR.	GA	HWE_2 (l°/kg)	HWE_7 (l°/kg)	C/F (l°/kg)	TSN (%)	TN (%)	SNR (%)	FERM (%)	VISC. (mPas)	FRIAB. (%)
7/17/7/17/4	H	-	317	313	4	0.47	1.32	36	86	1.66	89
	H	+	321	319	2	0.60	1.33	45	85	1.58	95
Trial: Rifle											
7/17/7/17/4	R	-	321	318	3	0.41	1.17	35	87	1.62	96
	R	+	323	321	2	0.44	1.19	37	85	1.57	98

TABLE IIIA: LAGER MALTS *EX* PILOT MALTINGS

1995 CROP, IOB WINTER TRIAL

ANALYSIS		TARGET SPECIFICATION	HALCYON CONTROL	GLEAM	PRELUDE	REGINA
H_2O	(%)	4 - 5	4.1	4.1	4.0	4.2
HWE_2	($l°kg^{-1}$)	310 - 315	314	311	309	310
HWE_7	($l°kg^{-1}$)	305 - 310	312	309	307	308
C/F	($l°kg^{-1}$)	2 - 5	2	2	2	2
Colour	(EBC)	2 - 3	3.4	3.0	2.9	3.7
SNR	(%)	38 - 42	40	43	42	43
FAN	(mgl^{-1})	140 - 180	125	152	162	169
FERM	(%)	74 - 78	74	75	77	74
Viscosity	(mPas)	1.45 - 1.65	1.54	1.58	1.50	1.56
Friability	(%)	> 85	97	95	98	94

TABLE IIIB: LAGER MALTS *EX* PILOT MALTINGS

1996 CROP, IOB SPRING TRIAL

ANALYSIS		TARGET SPECIFICATION	CHARIOT CONTROL	LANDLORD
H_2O	(%)	4 - 5	4.6	4.5
HWE_2	($l°kg^{-1}$)	310 - 315	311	306
HWE_7	($l°kg^{-1}$)	305 - 310	307	304
C/F	($l°kg^{-1}$)	2 - 5	4	2
Colour	(EBC)	2 - 3	2.4	2.5
SNR	(%)	38 - 42	32	34
FAN	(mgl^{-1})	140 - 180	113	155
Ferm.	(%)	74 - 78	75	75
Viscosity	(mPas)	1.45 - 1.65	1.57	1.49
Friability	(%)	> 85	94	96

TABLE IIIC: ALE MALTS *EX* PILOT MALTINGS

1996 CROP, IOB WINTER TRIAL

ANALYSIS		TARGET SPECIFICATION	HALCYON CONTROL	RIFLE
H_2O	(%)	3.0 - 3.5	3.8	3.9
HWE_2	($l°kg^{-1}$)	310 - 315	316	319
HWE_7	($l°kg^{-1}$)	308 - 312	312	319
C/F	($l°kg^{-1}$)	0 - 5	4	0
Colour	(EBC)	3.5 - 4.5	3.9	3.9
SNR	(%)	42 - 45	36	31
FAN	(mgl^{-1})	140 - 180	114	155
Ferm.	(%)	69 - 72	72	72
Viscosity	(mPas)	1.50 - 1.70	1.69	1.59
Friability	(%)	> 90	93	98

TABLE IVA: BOTTLED BEER ANALYSIS - BOTTLED LAGER

VARIETY	GLEAM	PRELUDE
pH	4.38	4.48
Colour (°EBC)	8.4	8.4
Present Gravity (°G)	8.58	7.24
Attenuation Limit (°G)	3.1	4.2
CO_2 (g/l)	4.63	-
HRV (NIBEM; s)	78	93,178,259
Bitterness (BU)	22	26
TSN (mg/l)	499	-
FAN (mg/l)	88.6	92.0
Ethanol (% v/v)	4.67	4.94

TABLE IVB: BOTTLED BEER ANALYSIS - BOTTLED LAGER

VARIETY	REGINA	HALCYON
pH	4.6	4.38
Colour (°EBC)	8.3	9.6
Present Gravity (°G)	7.8	9.14
Attenuation Limit (°G)	4.4	3.6
CO_2 (g/l)	-	-
HRV (NIBEM; s)	76,156,237	85
Bitterness (BU)	25	23
TSN (mg/l)	-	614
FAN (mg/l)	97.5	70.2
Ethanol (% v/v)	4.63	4.57

TABLE IVC: BOTTLED BEER ANALYSIS - LAGER

VARIETY	CHARIOT	LANDLORD
pH	4.13	4.17
Colour (°EBC)	9.1	10.7
Present Gravity (°G)	6.01	4.98
Attenuation Limit (°G)	3.18	2.58
CO_2 (g/l)	4.19	4.16
HRV (NIBEM; s)	82, 169, 252	97, 186, 269
Bitterness (BU)	19.7	19.5
TSN (mg/l)	557	507
FAN (mg/l)	47.1	61.3
Ethanol (% v/v)	4.9	5.13

TABLE IVD: BOTTLED BEER ANALYSIS - BEST BITTER

VARIETY	HALCYON	RIFLE
pH	4.18	4.12
Colour (°EBC)	20.6	19.8
Present Gravity (°G)	5.33	5.92
Attenuation Limit (°G)	4.17	3.01
CO_2 (g/l)	5.27	4.66
HRV (NIBEM; s)	90, 174, 254	106, 205, 290
Bitterness (BU)	23.3	25.4
TSN (mg/l)	330	276
FAN (mg/l)	21	16.5
Ethanol (% v/v)	4.12	4.13

APPENDIX A: PILOT MALTINGS PROCESSING

1995 Crop

STEEPING (16-17°C)

W8/A14/W10/A10/W6/A2 = 50h

(W = water; A = air rest)

ADDITIVES

The Halcyon control, Prelude and Regina were sprayed with GA at cast at the rate of 0.1ppm relative to the original barley weight. The Gleam trial was sprayed with 0.2ppm GA at cast

GERMINATION

For four days at

Day 1 = 15°C
Day 2 = 16°C
Day 3 = 17°C
Day 4 = 18°C

KILNING

All the malts received the same lager kilning schedule.

TIME (h)	AIR-ON TEMP (°C)	AIR-OFF TEMP (°C)	(%) RE-CIRC.
2	40	20	0
2	45	20-22	0
2	50	22-23	0
4	55	23-29	0
7	60	29-35	0
2	65	35-44	0
1	70	44-51	20
1	75	51-59	30
1	80	59-65	40
5	85	65-79	60
27	**TOTAL**		

APPENDIX B: PILOT MALTINGS PROCESSING

(i) 1996 crop Lager Malt Processing

STEEPING (16-17°C)

W8/A14/W10/A10/W2/A2 = 46h

(W = water; A = air rest)

PROCESSING AIDS

None

GERMINATION

For four days at

Day 1 = 15°C
Day 2 = 16°C
Day 3 = 17°C
Day 4 = 18°C

KILNING

The malts received the same lager kilning schedule.

TIME (h)	AIR-ON TEMP (°C)	AIR-OFF TEMP (°C)	(%) RE-CIRC.
2	40	20-21	0
2	45	21-23	0
2	50	23-25	0
4	55	25	0
2	60	25-26	0
9	60	26-35	0
2	65	35-52	90
1	70	52-57	90
1	75	57-63	90
1	80	63-68	90
5	85	68-79	100
31	**TOTAL**		

(ii) 1996 crop Ale Malt Processing

STEEPING (16-17°C)

W8/A14/W10/A10/W6/A2 = 50h

(W = water; A = air rest)

PROCESSING AIDS

0.1ppm GA at cast

GERMINATION

For four days at

Day 1 = 15°C
Day 2 = 16°C
Day 3 = 17°C
Day 4 = 18°C

KILNING

The malts received the same ale kilning schedule.

TIME (h)	AIR-ON TEMP (°C)	AIR-OFF TEMP (°C)	(%) RE-CIRC.
1.5	45	19-22	0
1.5	55	22-25	0
1	60	25-26	0
4	65	26-27	0
2	70	27-28	0
7	75	28-40	0
1.5	80	40-54	50
1.5	85	54-70	50
2	90	70-82	50
3	95	82-88	50
25	**TOTAL**		

APPENDIX C: IOB MALT ANALYSES

ANALYSIS	MEANING	UNITS
Moisture	moisture content of dried malt	% $^{w}/_{w}$
HWE (0.2mm)	Hot Water Extract: the maximum laboratory extract on fine grind	$l°kg^{-1}$ *
HWE (0.7mm)	coarse grind extract equivalent to best likely brewers extract. This result is used to rank NIAB malting grade. A good extract is 310$l°kg^{-1}$ (dry basis)	$l°kg^{-1}$ *
Fine Coarse Difference	= HWE_2 - HWE_7; this is an indication of the degree of modification <5 $l°kg^{-1}$ is satisfactory	$l°kg^{-1}$ *
Colour	colour of the HWE_7; it is an indication of the kilning temperatures used to dry malt. Colours 1.5 - 4 = lager 4 - 10 = ales	°EBC
TSN	soluble nitrogen content of HWE_7 results expressed as % of malt dry wt	% $^{w}/_{w}$ *
TN	total nitrogen content of dry malt TN x 6.24 = protein content of the malt	% $^{w}/_{w}$ *
SNR (Soluble nitrogen ratio)	$\frac{TSN}{TN} \times 100$ This is an indication of nitrogen modification (extent of protein solubilization) <35 = poor; 38 - 45 = well modified; >45 = overmodified	% *
FAN (Free amino nitrogen)	Measure of the amino acids present in HWE_7; these are important for yeast nitrogen metabolism. Typical wort range 140-220 mgl^{-1}	mgl^{-1}
pH	measure of acidity or alkalinity of HWE_7	-
Fermentability	true fermentability, based on forced fermentation result. A check that the wort containing the normal spectrum of fermentable sugars (normal range 70-75)	%
Viscosity	of HWE_7 measured at 20°C. High values (>1.7) may indicate presence of β-glucans, indicating poor endosperm cell wall degradation	mPa.s
Friability	measure of the hardness of malt. Low values (< 80%, indicate inadequate cell wall degradation and poor malt modification. However, inherent hardness of different barley varieties can affect	%

ANALYSIS	MEANING	UNITS
	this result	
Diastatic power	principally a measure of ß-amylase content. This enzyme is largely responsible for the production of fermentable maltose sugar, but needs to work in conjunction with α-amylase	°IOB
Dextrinizing units	principally, a measure of α-amylase	DU
*** Results expressed on a dry wt basis**		