HGCA

PROJECT REPORT No. 117

PILOT-SCALE MALTING AND BREWING TRIALS ON NEW BARLEY VARIETIES

NOVEMBER 1995

PRICE £3.00

PROJECT REPORT No. 117

PILOT-SCALE MALTING AND BREWING TRIALS ON NEW BARLEY VARIETIES

by

T. M. MORRIS, C. D. BOOER AND M. O. PROUDLOVE

BRF International, Lyttel Hall, Nutfield, Redhill, Surrey RH1 4HY

This is the final report of a three year project which commenced in February 1992. The work was funded by a grant of £84,325 from the Home-Grown Cereals Authority (Project No. 0024/01/91).

CONTENTS

OBJECTIVES

The aim of this project was to provide pilot scale malting and brewing data on new barley varieties. Data are used by the IOB, to assess the varieties for Provisional or Full Approval for malting, brewing and distilling.

SUMMARY

BRF International collaborates with the Institute of Brewing, by carrying out micro-malting (350 g), pilot malting (50 kg) and, subsequently, pilot-scale brewing (100 litres) on new barley varieties. The barleys for assessment were chosen by the English Working Party.

This project covers the crop years 1991–1994.

1991 CROP

The spring varieties, CHARIOT and DERKADO, and the winter variety BRONZE, were assessed.

The sample of Chariot clearly performed better than its site control, on both micromalting and pilot malting. During brewing, both the trial and control malts performed satisfactorily. The sample of Derkado was not supplied with a suitable site control, which made interpretation of the results difficult. However, despite the rather high nitrogen content, a malt of satisfactory specification could be produced under realistic conditions and successfully brewed.

Both Chariot and Derkado have since received full Approval from the IOB.

1992 CROP

The samples of Bronze, supplied from both 1991 and 1992 crops, suffered from excessively high nitrogen content. Although both were micromalted, subsequent pilot-scale trials were abandoned. No other barley varieties were made available for assessment from the 1992 crop. Bronze was rejected as a potential malting variety.

1993 CROP

The spring varieties, Brewster and Cooper, were chosen for assessment against Alexis as the site control, and they both justified their NIAB grade 9 for malting, although the

extract potential of Brewster seemed slightly higher than that of Alexis and Cooper. There was some indication that, in Brewster, protein modification was less easy than with Cooper; however, increased cast moisture, as a result of small corn size in the Cooper sample, may have been a contributory factor. Both the trial barleys produced satisfactory results in the pilot maltings. When they were brewed, no significant problems were observed in the brewhouse. Fermentation proceeded normally and, likewise, profile tasting of the resultant beers highlighted no major differences between either trial or control.

Brewster has subsequently not been recommended as a malting variety, whilst Cooper has received Provisional Recommendation *(Autumn 1994)* from the IOB.

1994 CROP

The winter varieties, MELANIE and FANFARE, were put forward for assessment; satisfactory malts and beer were produced, with no major problems being highlighted. There was evidence that extract, viscosity and friability results of the Melanie malt were poorer than with Fanfare. These differences may be due to the variation in nitrogen content of the two barleys tested.

ABBREVIATIONS

BRFI	:	BRF International
EWP	:	English Working Party
GA	:	Gibberellic acid
IOB	:	Institute of Brewing
MMWP	:	Micromalting Working Party
NIAB	:	National Institute of Agricultural Botany
OG	:	Original gravity
MALT ANALYSIS	:	Outlined in Appendix C

INTRODUCTION

In recent years, the efforts of plant breeders have resulted in an increase in the numbers of new varieties coming through the breeding programmes. It is important that these varieties are screened for malting potential to safeguard supplies of good quality malting barley. The IOB Barley Committee has a scheme for the Evaluation of New Barley Varieties which involves the co-operation of two sub-committees:

1. The Micromalting Working Party
2. The English Working Party

The MMWP is responsible for organizing the micromalting trials with a range of collaborating groups (including BRFI), discussion of the results and reporting to the EWP. The EWP, in turn, discusses the MMWP report and agrees conclusions which form the recommendations put forward to the IOB Barley Committee. In addition, Pilot Malting and Brewing trials, performed at BRFI (summarized p iv-v), have also been assessed by the EWP, to enable the IOB Barley Committee to award either Full Approval (denoted by an asterisk) or Provisional Approval (denoted by an asterisk in parenthesis) to barley varieties which are suitable for malting, brewing and distilling. The current Approved variety list for 1995-1996 (UK) is shown in Appendix A.

MATERIALS AND METHODS

BARLEYS

The barleys (1994 crop) selected by the EWP for pilot studies were:

Melanie & Fanfare	Winter varieties under test
Halcyon	Site control

These samples were grown by NIAB, in their trial plot at Cambridge.

MALTING PROTOCOLS

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

GERMINATION TESTS

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

Any corns which are alive will be stimulated to germinate (even the dormant ones).

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

Water Sensitivity: (8ml plate; 72h; 16°C) gives a measure of the susceptibility of the embryo development to excess water.

Provided the barley sample has a germinative energy greater than or equal to 95% then further assessment can proceed.

Routine Micromalting Assessment

The 350g Micromalting facility is used for this purpose.

Two standard steeping procedures are employed:

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

(ii) 7h wet/17h air rest/7h wet/17h air rest/1h wet.

Steep schedule (i) minimizes air rest time and maximises immersion time whilst schedule (ii) does the opposite. Both are 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 are processed in duplicate, one set being sprayed with gibberellic acid 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 follows the steeping. At the end of this stage, the green malt is dried on shallow trays in a forced draught oven for 24h (8h @ 45°C; 16h @ 65°C).

The finished malts are then analyzed for a range of parameters including extract, nitrogen, viscosity, fermentability and friability.

Pilot Malting

Information obtained from micromalting on the 350g scale can then be used to devise malting schedules for production of pilot scale batches using the BRFI 50kg malting plant[1]. The process conditions employed are shown in Appendix B.

ANALYSIS OF BARLEY, MALT, WORT AND BEER

These measurements were all made using IOB Recommended Methods[2]. 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 100 litre Pilot Brewery at BRFI. The pilot malts were used to brew BRFI Premium lagers (OG 1044) according to standard BRFI protocols.

The brewhouse comprises a modern system incorporating a stirred mashing-in vessel; lauter-tun; kettle; whirlpool and wort receiver. A programmed temperature mash was carried out in the mashing vessel, and held at 64°C for 1h. A temperature ramping, to 78°C in 14 mins, was 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. After boiling the wort for 1.5h, transfer to the whirlpool for wort clarification was followed by dilution to standard gravity in the wort receiver. Thereafter the wort was cooled to 12°C and 60 litres 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 chilled to 0°C.

RESULTS AND DISCUSSION

The 1994 crop barleys presented for pilot–malting trials comprised the two winter varieties Fanfare and Melanie, with Halcyon as the site control. On receipt, the barleys were dried, screened and submitted for the usual analyses, see Table I. All three barleys were suitable for malting and were not at all dormant or water sensitive. Thousand corn weights showed that the grains of the Melanie sample were significantly larger than either Halcyon (control) or Fanfare: this was confirmed by sieve analysis. There was a significant difference in barley nitrogen, with both the Halcyon and Fanfare being relatively low ($\leq$ 1.4% TN).

Prior to pilot scale trials, micromalting was carried out according to the methods described in (2.2). Malts were prepared with and without GA for each steeping procedure and the results are shown in Tables II A–C.

The Halcyon control exhibited good HWE values, even when GA was not employed. However, protein modification was poor, in the absence of externally–added GA. As expected, extract, TSN, SNR, FAN, viscosity and friability were all improved when GA was sprayed on at cast.

The HWE values achieved, when the Melanie barley was malted under the same conditions, were low in comparison with the control when GA was not used. Protein modification showed a similar pattern to the Halcyon malt. These indicators both recovered in the presence of GA, to give similar values to the equivalent control malts, although malt viscosity and friability remained poor.

Malting of the Fanfare trial resulted in HWE values that were higher than those achieved with Melanie, and similar to those of the Halcyon control. Viscosity values were the lowest observed for the three malts, and friabilities the highest. When GA was employed, in conjunction with the two–steep process, both Halcyon and Fanfare

exhibited high SNR values of 48%, indicating over-modification of the protein component of the malts.

Table III shows the analytical values for the three lager malts produced in the Pilot Maltings. The same process conditions were used for each variety and are detailed in Appendix B. In all three cases, the majority of the target specifications set for the pilot-scale malt were met: the only exceptions were slightly low FAN values with Halcyon and Fanfare. The trends noticed from the preliminary micromalting were also seen here, Melanie having the lowest extract, highest viscosity and lowest friability. Under these conditions, the SNR for Fanfare was slightly lower than that achieved with Halcyon and Melanie. However, all the malts were entirely suitable for brewing.

All three pilot malts were brewed as premium lagers using the procedure described in Section 2.4. All the malts passed uneventfully through the brewhouse and performed normally. The pitching wort analyses are shown in Table IV. Owing to unforeseen circumstances, no analysis of the pitching wort, produced from the Fanfare malt, is available. The only significant difference between the Halcyon control and Melanie trial worts was the fermentability, which was higher in the trial.

Table V shows the analyses of the bottled beers, which were broadly within the range normally associated with this product, with the exception of the TSN and FAN values for the control and Fanfare beers. These low nitrogen values can be related back to the relatively low barley nitrogens observed with the Halcyon control and Fanfare trial, and are, hence, raw material based. However, this appears to have had little effect on either the theoretical attenuation limit or ethanol levels in the bottled beers, which were normal. Present gravity results were slightly high, but this was more likely to be a reflection of the yeast used, than anything to do with the malts or worts produced.

Profile tasting of the beers was carried out, using an experienced panel of tasters, in accordance with established procedures. All three beers were very similar to BRFI standard lager. No one beer stood out as being different, and there were no significant off-notes.

CONCLUSIONS

Both Melanie and Fanfare produced pilot scale malts which were suitable for brewing and gave no problems during brewhouse operations. Similarly, satisfactory beers were produced.

Overall, the malting results showed that Melanie has a significantly lower extract and friability, with higher viscosity, than Fanfare. These differences may well, in part, be due to the differences in nitrogen content of the trial barleys.

TABLE I: BARLEY ANALYSES

1994 CROP, IOB PILOT TRIALS

	HALCYON 94/235	MELANIE 94/236	FANFARE 94/237
ANALYSIS			
H_2O (%)	10.8	10.6	11.0
TN (%)	1.40	1.57	1.38
SIEVE (MM)			
> 2.8	53.0	76.1	*
2.5 – 2.8	36.1	19.6	*
2.2 – 2.5	8.1	3.0	*
< 2.2	2.8	1.3	*
*** sample screened before sieve analysis performed**			
GERMINATION TESTS (%)			
Capacity	98	96	96
Energy	98	96	96
Water Sensitivity	91	88	87
Thousand Corn weight (TCWg)	38.7	45.5	40.2

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

HALCYON 94/235

STEEP	GA	HWE_2 (ℓ°/kg)	HWE_7 (ℓ°/kg)	C/F (ℓ°/kg)	TSN (%)	TN (%)	SNR (%)	FAN (mg/l)	FERM (%)	VISC. ($mPas^{-1}$)	FRIAB. (%)
8/16/24	–	315	311	4	0.50	1.46	34	88	77	1.71	80
	+	320	318	2	0.68	1.41	48	141	75	1.51	91
7/17/7/17/1	–	315	311	4	0.49	1.42	35	88	75	1.60	78
	+	318	314	4	0.60	1.43	42	118	76	1.52	87

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

MELANIE 94/236

STEEP	GA	HWE_2 (ℓ°/kg)	HWE_7 (ℓ°/kg)	C/F (ℓ°/kg)	TSN (%)	TN (%)	SNR (%)	FAN (mg/l)	FERM (%)	VISC. ($mPas^{-1}$)	FRIAB. (%)
8/16/24	–	311	301	10	0.46	1.41	33	83	76	1.78	58
	+	317	311	6	0.64	1.41	45	142	76	1.59	77
7/17/7/17/1	–	311	306	5	0.48	1.39	35	96	75	1.72	70
	+	315	313	2	0.63	1.38	46	135	77	1.64	79

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

FANFARE 94/237

STEEP	GA	HWE_2 (ℓ°/kg)	HWE_7 (ℓ°/kg)	C/F (ℓ°/kg)	TSN (%)	TN (%)	SNR (%)	FAN (mg/l)	FERM (%)	VISC. ($mPas^{-1}$)	FRIAB. (%)
8/16/24	–	315	313	2	0.48	1.34	36	88	76	1.59	83
	+	319	317	2	0.64	1.33	48	132	77	1.48	95
7/17/7/17/1	–	314	309	5	0.47	1.35	35	114	75	1.57	85
	+	317	315	2	0.58	1.36	43	144	77	1.52	91

TABLE III: LAGER MALTS *EX* PILOT MALTINGS

1994 CROP, IOB WINTER TRIAL

ANALYSIS		TARGET SPECIFICATION	HALCYON CONTROL	MELANIE	FANFARE
H_2O	(%)	4 – 5	5.0	4.2	4.4
HWE_2	($\ell°kg^{-1}$)	310 – 315	314	312	315
HWE_7	($\ell°kg^{-1}$)	305 – 310	312	309	312
C/F	($\ell°kg^{-1}$)	2 – 5	2	3	3
Colour	(EBC)	2 – 3	3.1	2.8	2.6
SNR	(%)	38 – 42	43	44	39
FAN	(mgl^{-1})	140 – 180	114	140	113
FERM	(%)	74 – 78	75	75	75
Viscosity	($mPa\,s^{-1}$)	1.45 – 1.65	1.52	1.59	1.52
Friability	(%)	> 85	89	85	93

TABLE IV: PITCHING WORT ANALYSES

	HALCYON CONTROL	MELANIE	FANFARE
pH	4.69	4.59	NA
Colour (EBC)	11	13	NA
Gravity (°G)	42.6	41.9	NA
TSN ($mg\ \ell^{-1}$)	783	795	NA
FAN ($mg\ \ell^{-1}$)	142	152	NA
Fermentability (%)	69	74	NA
Bitterness (BU)	25	26	NA

TABLE V: BOTTLED BEER ANALYSES

	HALCYON CONTROL	MELANIE	FANFARE
pH	4.22	4.21	3.94
Colour (EBC)	9	10	8
Head retention value (secs)	88	88	88
Present gravity (°G)	10.4	11.9	9.2
Bitterness (BU)	16	20	19
FAN ($mg\,\ell^{-1}$)	34.4	57.1	28.6
TSN ($mg\,\ell^{-1}$)	485	602	468
Attenuation limit (°G)	5.0	4.8	5.1
Ethanol (% v/v)	4.20	4.19	4.56

APPENDIX A: IOB APPROVED VARIETIES

1995–1996 SEASON – UK

WINTER:

Halcyon			
Pipkin	☆		
Puffin	☆		
Sprite	☆☆		
Fanfare		}	Provisional
Melanie		}	

SPRING:

Chariot			
Derkado			
Alexis	☆		
Prisma	☆☆		
Cooper		}	
Optic		}	(Provisional)
Delibes	☆☆	}	

☆	=	Approved for central / south–east / south–west only
☆☆	=	Approved for north–east / north–west only

APPENDIX B: PILOT MALTINGS PROCESSING

STEEPING (16–17°C)

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

(W = water; A = air rest)

ADDITIVES

All three barleys were sprayed with GA at cast at the rate of 0.1 ppm relative to the original barley weight

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
6	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
26	**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	$\ell°kg^{-1}$ *
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 $\ell°kg^{-1}$ (dry basis)	$\ell°kg^{-1}$ *
Fine Coarse Difference	= HWE_2 – HWE_7; this is an indication of the degree of modification <5 $\ell°kg^{-1}$ is satisfactory	$\ell°kg^{-1}$ *
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)	$\frac{TSN}{TN}$ x 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}	$mg\ell^{-1}$
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

ANALYSIS	MEANING	UNITS
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 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**		

REFERENCES

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

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