PROJECT REPORT No. 259

MALTING AND BREWING CHARACTERISTICS OF NEW MALTING BARLEY VARIETIES (WINTER - LEONIE, OPAL, VANESSA; SPRING - CELLAR, COUNTY, PEWTER) (2000/2001 TRIALS)

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by

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This report presents the results from the third year of trials from a three-year project which started in July 1998. The work was funded by a grant of £77,993 from HGCA (project no. 1200).

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1. EXECUTIVE SUMMARY

1.1 Samples of three new winter (Leonie, Opal & Vanessa) and three new spring barleys (Cellar, County & Pewter) were assessed for malting and brewing quality. Each variety was compared with a control grown at the same site with the exception of Vanessa.

1.2 Within a set all samples were malted on a small scale using identical conditions. This allowed malting performance to be compared and also indicated the most appropriate conditions for pilot scale malting.

1.3 Each barley was then malted on the pilot scale using the conditions best suited for that variety, in order to try and produce a malt which matched an agreed lager malt specification.

1.4 Each malt was then brewed using identical processing conditions to produce an 11°P lager.

1.5 Barleys, malts, worts and beers were analysed using standard IOB methods. Barley endosperm quality was also assessed using the Light Transflectance Meter, which is a new instrument developed at BRI as a result of HGCA-funded work (Project Report Nos141and 238).

1.6 Winter Barleys

As a group, this set of barleys had poor endosperm structure and produced generally undermodified malts with particularly high beta-glucan levels. These samples would not have been acceptable for commercial malting and brewing in the UK.

1.6.1 **Leonie** is a small grained variety. There were no dormancy problems and micromalting performance was at least as good as the Halcyon control. Pilot malting, brewing and fermentation performance was good and this variety has received Provisional 1 status on the IOB Recommended List 2001/2002.

1.6.2 **Opal** may be a nitrogen scavenger and the TN of this sample was high. It also produced malt with a low extract, high β-glucan and very low friability. Brewhouse and fermentation performance were poor and the beer had a pronounced sulphury note.

1.6.3 **Vanessa** had been assessed last year (1999 crop) but because the barley quality was poor, trials were repeated with barley from the 2000 harvest. This sample was of much better quality being large grained with a reasonable nitrogen. However endosperm quality was very poor (steely). Yet, high extracts were obtained on malting and viscosity was low, as was proteolysis. Although standard analyses did not indicate any major problems, brewhouse performance was very poor with high pressure differentials developing during lautering and very turbid worts. Attenuation was poor so that the final gravity remaining at the end of fermentation was high.

1.7 Spring Barleys

1.7.1 **Cellar** This sample had very good endosperm structure and passed through all the micro malting and pilot stages performing at least as well as the Optic control. It gave malts of good friability and DP potential. Brewhouse and fermentation performance were good and this variety has received Provisional 1 status on the IOB Recommended List 2001/2002.

1.7.2 **County** Although of good quality this sample was found to produce malts with raised β-glucan levels. Extract and protein modification were similar to, but not better than the Optic control. There were no problems with either brewhouse or fermentation performance.
1.7.3 **Pewter** This variety was large grained with good endosperm structure and malting characteristics. Protein modification was good with higher production of FAN than the Optic control. DP potential was lower than the control. Pewter met all the pilot malting specifications and there were no brewhouse or fermentation problems. During the English Micromalting Group (EMMG) collaborative micromalting it was noted that Pewter appeared prone to grain splitting.

A copy of the current IOB Approved Variety List (as of July 2001) is included as Annex 4.

2. SCOPE OF PROJECT

The objective of the trials was to determine whether new varieties are suitable for use for malting and brewing when grown in the UK. The varieties tested from the 2000 crop were:
Winters **Leonie, Opal** and **Vanessa**
Springs **Cellar, County** and **Pewter**

The trials involve malting each barley, together with the appropriate fully IOB approved variety as a control, on a small scale (350g) and on the pilot scale (50 kg). For the small-scale trials, all barleys were subjected to the same conditions, so that the malting performance of the new varieties can be assessed. This information was used to adjust the pilot malting process conditions for each variety in order to produce malt of a suitable specification for pilot brewing trials. The brewing quality of each malt was then evaluated by brewing on the pilot scale (100 litres). All barleys, malts, worts and beers were analysed for standard quality parameters by IOB recommended methods. The flavour of each beer was assessed by the BRi Profile panel.

3. BARLEY SAMPLES PROVIDED

BRI Reference	Type	Variety	Site
00/6	Winter	Leonie	N.Yorks
00/7	Winter	Opal	N.Yorks
00/31	Winter	Vanessa	Beds
00/9	Winter	Halcyon (control)	N.Yorks

The sample of Vanessa had to be sourced outside the ADAS trial and so no appropriate control was available.

BRI Reference	Type	Variety	Site
00/33	Spring	Cellar	Lincs
00/34	Spring	County	Lincs
00/36	Spring	Pewter	Lincs
00/38	Spring	Optic (control)	Lincs

RESULTS OF MALTING AND BREWING TRIALS

A. Winter Varieties

1. Barley Quality

Results of analyses for standard barley quality parameters are shown in **Table 1.** The nitrogen content of Leonie, Vanessa and Halcyon was at a similar and reasonable level. However that of Opal was rather high and may indicate that it is a nitrogen scavenger. All showed good viability and were not dormant at the time of malting. Opal and Halcyon were both quite water sensitive. Leonie was a small grained variety similar in size to Halcyon. Both Opal and Vanessa were large, with Vanessa being the boldest sample and this was reflected in the thousand corn weight (TCW) values.

Table1. Barley Analyses

Variety	Leonie	Opal	Vanessa	Halcyon (control)
Barley Ref.No.	00/6	00/7	00/31	00/9
Moisture (%) (after drying)	11.7	11.8	12.6	11.7
Total Nitrogen (%)	1.77	1.92	1.75	1.70
TCW (g)	35.5	41.7	46.8	35.7
Sieve Analysis (g)				
> 2.8	29.7	88.7	92.2	42.2
2.5-2.8	53.0	7.7	5.0	42.4
2.2-2.5	14.4	2.5	1.7	12.2
<2.2	2.9	1.1	1.1	3.2
Viability (%)	95	97	98	99
Germinative Energy (%)	99	94	98	97
Water Sensitivity (%)	60	32	78	26

Endosperm quality was examined using the Light Transflectance Meter (see Annex 3). The LTM value is measured on 97 grains and gives a value (mV) for each grain. These results are grouped in 100 unit bands and values < 200 are classed as having mealy endosperm structure. The percentage grains in the sample having mealy endosperm was Leonie 37%, Opal 76%, Vanessa 14%, and Halcyon 26%. All these samples therefore exhibited low mealiness scores with those of Leonie, Halcyon and Vanessa being exceptionally poor. This indicates that the malting quality of these samples is likely to be below that normally expected from commercial suppliers.

2. Micro-malting

Each sample was micro-malted under two sets of conditions (with and without gibberellic acid) in order to compare malting performance (**Table 2**).

Table 2. Malt Analyses small scale malting[1]

Parameter	**No added Gibberellic Acid**				**With Gibberellic Acid**			
Variety	Leonie	Opal	Vanessa	Halcyon	Leonie	Opal	Vanessa	Halcyon
Barley Ref. No.	00/6	00/7	00/31	00/9	00/6	00/7	00/31	00/9
Hot Water Extract (litre°/kg)								
fine grind	308	310	314	309	309	311	317	311
coarse grind	305	304	308	303	308	306	314	307
Total Soluble Nitrogen (%)	0.62	0.58	0.56	0.59	0.71	0.70	0.68	0.68
Total Nitrogen (%)	1.67	1.84	1.65	1.72	1.67	1.78	1.57	1.69
Soluble Nitrogen Ratio	37	32	34	34	43	39	43	40
Free Amino Nitrogen (mg/litre)	158	131	132	152	189	178	171	176
Fermentability (%)	83	83	83	83	81	83	82	81
Viscosity (mPa/s)	1.59	1.67	1.57	1.66	1.58	1.65	1.54	1.61
DP °IOB	138	140	102	139	161	148	119	139
DU	49	24	29	38	55	28	35	46
Wort Clarity	Clear	Sl.cl	Clear	Clear	Clear	Clear	Clear	Clear
Fine/ Concentrated Mash Difference	9	20	20	15	7	15	16	9
Viscosity of 70°Mash	4.28	4.82	4.98	4.97	4.16	3.93	4.92	4.21
Friability (%)	75	67	77	73	81	77	83	81
Homogeneity (%) [2]	96.7	86.4	97.2	94.4	98.7	93.6	98.6	98.2

[1] *Malting schedules: 7h wet/17h air/7h wet/17h air/3h wet + 4 days at 16°C +/- gibberellic acid (0.2ppm).*
[2] *from friability measurement*

Carbohydrate Modification

Only Vanessa had a significantly better extract than the Halcyon control. In the case of Opal this may be due to the higher nitrogen content of the barley. This trend was also observed when GA was used. Fine/concentrated mash difference

was consistently high for both Opal and Vanessa but all the results of the 70°C mash viscosity test were low which indicates that there should be no problems with carbohydrate hydrolysis.

Protein Modification

In the absence of GA, all the barleys were low protein modifiers. Total soluble nitrogen values (TSN) of the trials were similar to the Halcyon control, with Leonie having the edge and Vanessa showing a slight dip in the absence of GA. This was confirmed by soluble nitrogen ratio (SNR) which was highest for Leonie. Opal exhibited the lowest SNR, reflecting its high total nitrogen level. These effects were minimised when GA was used. Free amino nitrogen values were all similar.

Cell-wall Modification

As a general note all the winter malts showed high beta-glucan levels, which may be linked to the poor endosperm structure observed in the barleys (see low mealy scores as assessed by Ltm; Annex 3). Opal showed a particular problem in this area. It had the highest viscosity values for HWE7 extract, especially when GA was used. This variety also gave high scores in the fine/concentrated mash difference test, both with and without added GA. Collaborative micro-malting trials carried out by the IOB's English Micro-Malting Group (EMMG) suggest that these results are linked with very high beta-glucan levels in Opal malts and may be indicative of a cell-wall hydrolysis problem with this variety. Friability and homogeneity were also low with Opal and both these can be markers for poor cell-wall breakdown. There were some anomalies in the case of Vanessa which produced malts with the lowest viscosity values but, like Opal, gave very high fine/concentrated mash difference values. Leonie showed no problems in this area (lowest beta-glucan of the set), performing at least as well as the Halcyon control.

Amylolytic Enzyme Potential

Leonie and Opal showed DP values (principally β-amylase) similar to the control Halcyon, however Opal DU values (α-amylase) were significantly low. Overall the DP potential of Vanessa was low.

3. Pilot Malting

Malting protocols
The winter samples were malted in the pilot plant and conditions were slightly varied to try and achieve the lager malt specification which is highlighted in **Table 4**. GA was not used, consistent with the requirement to produce a lager malt. Germination times were kept constant at four days for all the malts.
The same kilning schedule was used for all the pilot malts but variations in the pre-break period (due to climatic conditions) meant that total kilning time varied between 24 and 30 hours.

Exact details of the malting conditions are given in the **Annex 1, Table 1**.

The control for this sample set was Halcyon. Process data for each barley is given in **Table 3**.

Table 3. Pilot Malting, Process data

Variety	Leonie	Opal	Vanessa	Halcyon
Barley Number	00/6	00/7	00/31	00/9
Malt Batch Number	852 P	858 P	859 P	853 P
Casting moisture(%)	46.9	45.0	46.0	45.3
Moisture at end of Germination (%)	44.4	42.7	43.7	43.2
Time to break point (hr)	24	9	9	21
Total kilning time (hr)	34	22	19	31

For technical reasons involving kilning control, both the Opal and Vanessa were malted at half the normal batch size. This explains the shorter kiln times. To ensure that this had not affected the process, the finished malt analysis was checked against a previous full batch size analysis and no relevant differences were noticeable.

Malt yield ; this was good for all varieties, at 85-86% “as is”.

Malt Quality

Malt analysis data is given in **Table 4.**

It is important to stress that the malting conditions were varied for each variety with the aim of achieving a target specification. SNR and FAN values were low for all three trials and also for the control variety. However this is indicative of the process used rather than a reflection of barley quality and with hindsight the protein modification could have been improved by allowing an extra day’s germination.

Although protein modification in general was low, this did not preclude any of the malts going forward for brewing.
The β-glucan target specification (100 mg/litre maximum) was exceeded by all the malts in this sample set. This is not indicative of any malting process failure but is a characteristic of these barley samples, however they were the best available. Although malted to try and achieve a target specification, the same trends previously seen in micromalting were noticeable again. Vanessa had the highest extract and lowest viscosity. Leonie was confirmed as the best protein modifier (highest SNR and FAN values), whilst also having a low viscosity. Opal exhibited the lowest coarse grind extract, highest β-glucan and very low friability.

Table 4. Pilot malting, winter malt analyses

ANALYSIS	TARGET SPECIFICATION	LEONIE	OPAL	VANESSA	HALCYON Control
Barley number	**-**	00/6	00/7	00/31	00/9
Malt Batch number	**-**	852 P	858 P	859 P	853 P
Moisture (%)	**4.0-5.0**	4.5	4.8	4.9	4.9
HWE2 (l°/kg dry)	**310-315**	308	306	312	308
HWE7 (l°/kg dry)	**305-310**	305	299	309	302
F/C Diff	**5 max**	3	7	3	6
Colour (EBC)	**2.0-3.0**	2.6	2.2	2.2	2.5
DP (°IOB)	**75 min**	102	89	81	92
TN (%dry)	**1.60-1.80**	1.72	1.85	1.62	1.75
SNR (%)	**38-42**	36	31	33	32
FAN (mg/l)	**140-180**	132	104	106	119
Fermentability (%)	**74-78**	76	71	73	72
Friability (%)	**85 min**	82	68	83	77
Homogeneity (%)	**96 min**	98.0	88.4	96.8	94.2
Beta- Glucan (mg/l)	**100 max**	160	311	158	255
Viscosity mPas	**1.45-1.65**	1.60	1.70	1.58	1.68

DMS Potential
It is recognised that variation in kilning and brewing conditions will affect the actual levels of DMS-p in the malt and wort, as well as the DMS in the final beer.

However, information on the capacity of a variety to produce DMS precursor is useful information for maltsters to have.
It was agreed at the Barley Committee, prior to this trial, that in order to eliminate variations due to kilning, DMS-p potential would be measured on green malt.
The results in Table 5 have been normalised relative to the Halcyon control. They show that the potential of Leonie to form DMS-p is higher than that of Halcyon, whilst that of both Opal and Vanessa is lower than the control.

Table 5. Potential for DMS precursor

VARIETY	POTENTIAL DMS-precursor (taking Control as 100 units)
HALCYON	100
LEONIE	114
OPAL	91
VANESSA	85

Foot note: DMS-p analysis was carried out on green malt at approximately 45% moisture.

These results broadly agree with the apparent potential of the varieties for proteolysis during malting.

4. Pilot Brewing

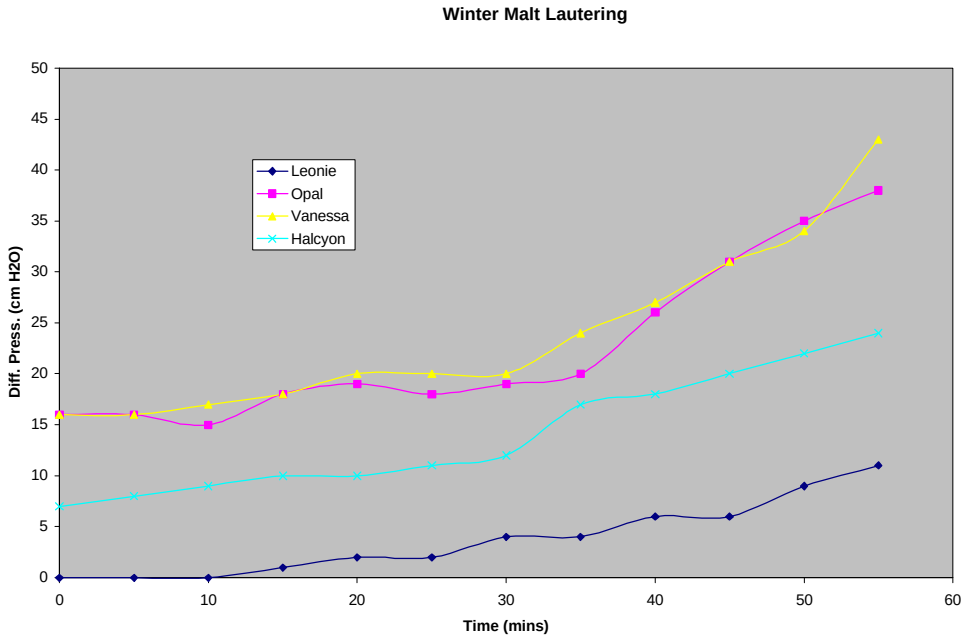
The pilot malts were used for brewing in the BRI pilot brewery, using standard process conditions for BRI 11°Plato lagers. Details of these are given in the **ANNEX 2.** Process data for each brew is given in **Table 6.**

Table 6. Pilot brewing, process data

Parameter	Leonie	Opal	Vanessa	Halcyon
Brew No.	15/01	16/01	20/01	13/01
Barley No.	00/6	00/7	00/31	00/9
Malt No.	852 P	858 P	859 P	853 P
Lauter time (min)	82	86	77	81
Gravity of last runnings (°gravity)	N/A	1008.3	1007.2	N/A
Wort clarity	Good	Good	Hazy	Good
Trub settling time (min)	30	30	30	30
Final wort gravity pre-fermentation	1044.5	1044.3	1043.6	1043.8
Total volume wort (litres)	98	92.5	99	92
Yeast viability at harvest (%)	90	90	91	91
Final gravity (°)	1006.8	1009.4	1009.8	1006.4
Gravity drop (° of gravity)	37.7	34.9	33.8	37.4

The differences in the lautering time seem small, because wort run-off is pumped. However, there were significant differences in the wort run-off performance. This was assessed by measuring differential pressure (ΔP) across the lauter tun bed during wort run-off (see **Fig 1**).

Fig 1:



Leonie performed well, showing only a small increase in ΔP and a better wort run-off than that of the Halcyon control. Both Opal and Vanessa had a significantly poorer lautering performance with rapidly increasing ΔP after 30mins. The wort turbidity with Vanessa was also very high and remained at 20-17EBC throughout, despite raking and recirculation for 50 mins prior to starting and additional raking at 55mins. Opal required deep bed raking at 63mins. Pilot lautering performance was therefore ranked : Leonie>Halcyon>Opal>Vanessa
Inspite of this, satisfactory extracts were achieved for all the malts which broadly were in line with that predicted from the laboratory analysis. Pilot brewery extract was ranked as :
Vanessa>Leonie> Opal>Halcyon
It is worth noting that commercial breweries can be more sensitive to lautering difficulties than pilot plants and that penalties on extract efficiencies and throughput, not seen on the small scale, may become very significant if lautering performance is poor.

Wort analyses are shown in **Table 7.**
Colour, pH, OG and BU are all within the normal ranges.

Table 7. Wort Analyses

Parameter	Leonie	Opal	Vanessa	Halcyon
Brew No.	15/01	16/01	20/01	13/01
Barley No.	00/6	00/7	00/31	00/9
pH	5.66	5.77	5.40	5.57
Colour (°EBC)	10.5	9.3	11.3	10.9
Original Gravity °	43.9	43.0	43.09	43.5
Bitterness (BU)	34	36	29	27
Free Amino Nitrogen (mg/litre)	159	137	131	162
Total Soluble Nitrogen (mg/litre)	805	744	679	746
Fermentability (%)	71	68	68	70

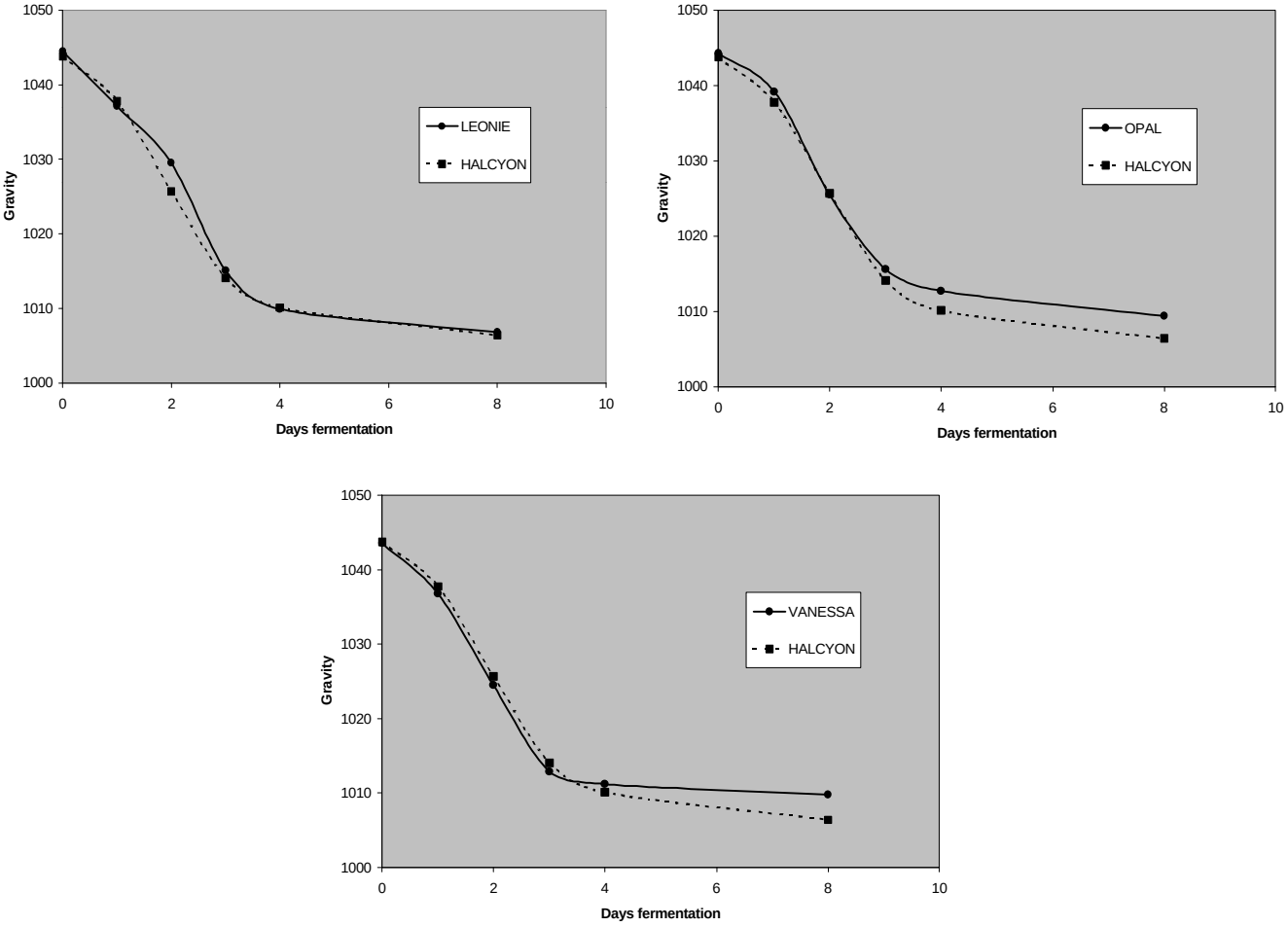
The FAN for Vanessa is rather low and both Opal and Vanessa exhibit low wort fermentability.

Fermentation Performance

Fermentation profiles for the trial beers are shown in **Figure 2**. Results for each variety are plotted separately against the Halcyon control.
The final gravity at the end of fermentation was high for both the Opal and Vanessa, indicating poor attenuation.The low soluble nitrogen level in these worts might be a contributory factor.

Figure 2. Fermentation profiles for beers

Each variety is plotted separately against the control.



5. Beer Quality and Flavour

Results for standard beer quality analyses are shown in **Table 8.**

Table 8. Pilot brewing, beer analyses, standard parameters

Parameter	Leonie	Opal	Vanessa	Halcyon
Brew No.	15/01	16/01	20/01	13/01
Barley No.	00/6	00/7	00/31	00/9
pH	4.31	4.11	3.96	4.11
Colour (°EBC)	6.8	8.0	6.9	7.9
Present Gravity (°)	5.22	10.0	8.51	6.6
Attenuation limit (°)	5.47	8.0	7.29	7.1
Head Retention Value (Nibem) (sec)	71,137, 204	81,161, 236	69,138, 205	71, 140, 203
Bitterness (BU)	21	22	18	23
Free Amino Nitrogen (mg/litre)	48.7	46.5	29.1	47.7
Total Soluble Nitrogen (mg/litre)	367	398	221	379
Ethanol (% v/v)	5.06	4.48	4.35	4.99

The values for pH foam and bitterness are all within specification.
The attenuation limits of over 7.3 ° of gravity correlate with the low wort fermentability, high final gravity and reduced alcohol content for both Opal and Vanessa. The low FAN in the Vanessa beer is also notable. The particularly high attenuation limit of the Opal beer may suggest that the carbohydrate spectrum was unsatisfactory.

Beer colour broadly corresponds to the colour values for the corresponding malt. Soluble nitrogen is in line with pitching wort values.

Beer Flavour

The aroma and taste of each beer was assessed by BRI's trained flavour profile panel. These results are presented as "spider diagrams" in **Figures 3-6**

Figure 3. Aroma and Taste scores for Leonie beer

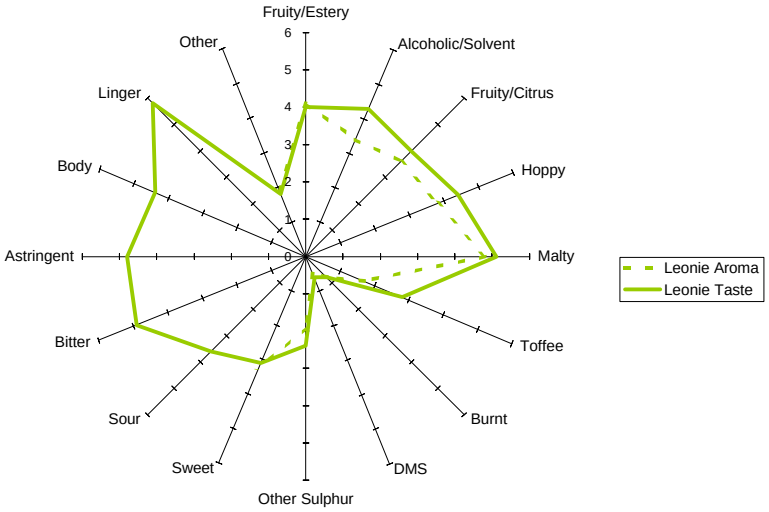


Figure 4. Aroma and Taste scores for Opal beer

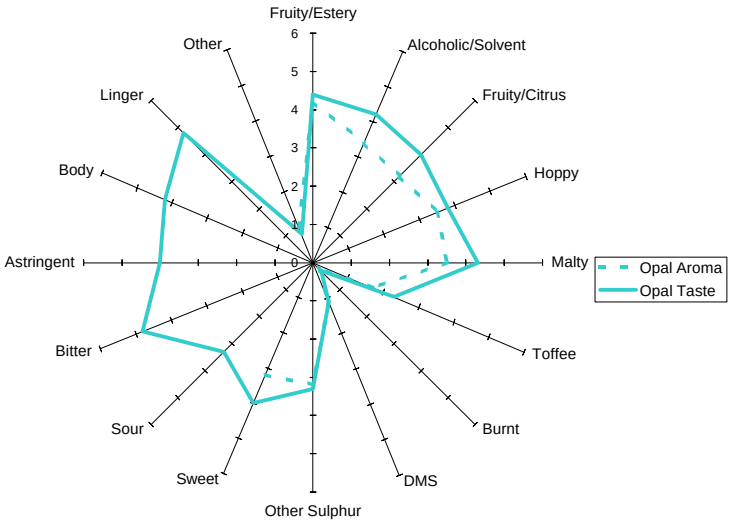


Figure 5. Aroma and Taste scores for Vanessa beer

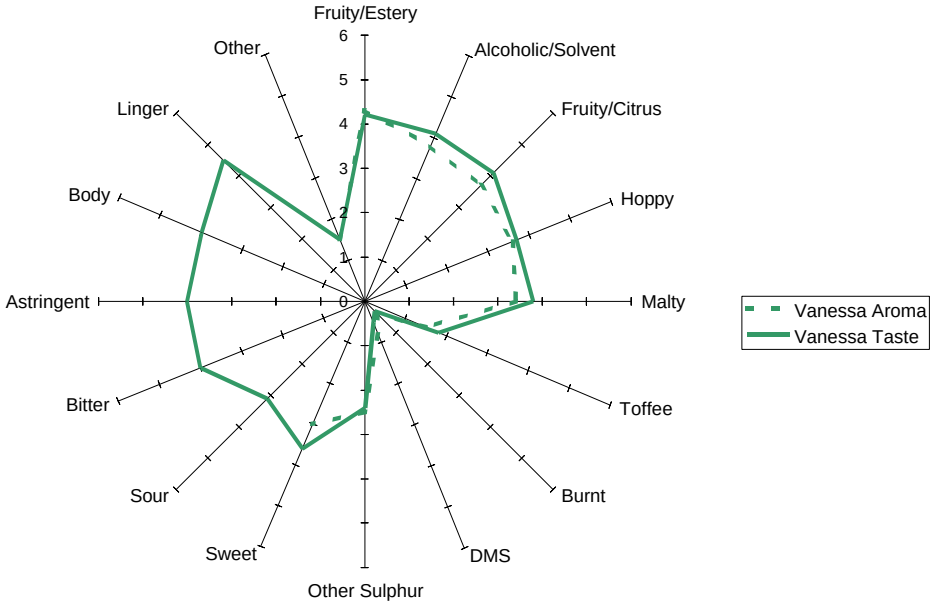
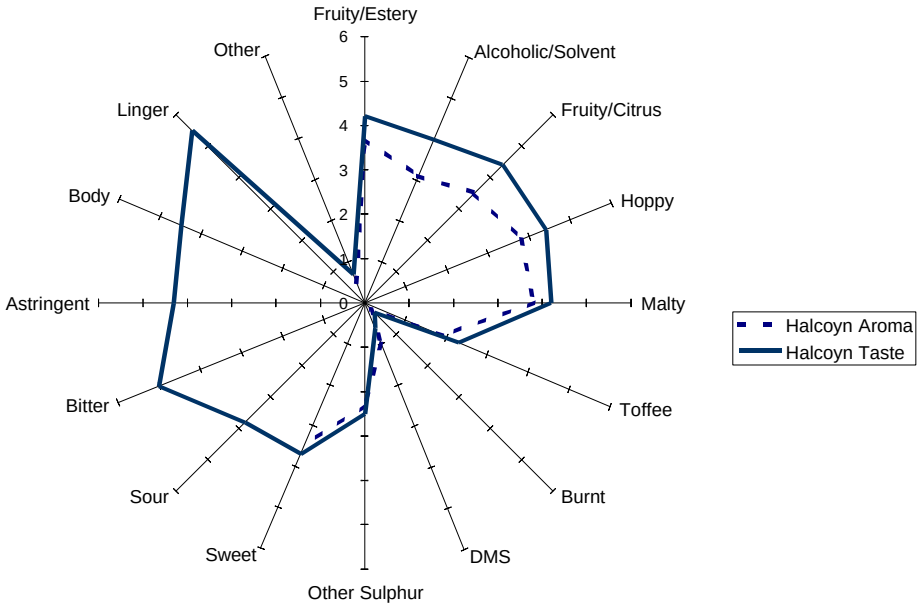


Figure 6. Aroma and Taste scores for Halcyon beer



Essentially all the beers were similar in character but some differences can be highlighted:

Significant differences on taste with respect to Halcyon

- Vanessa is significantly less hoppy, sour and bitter than Halcyon.
- Leonie is significantly more malty than Halcyon.
- Opal is significantly more sulphury than Halcyon.
- Halcyon has a significantly longer linger than Opal and Vanessa.

Leonie and Vanessa had a distinct malt character described as grainy and harsh. It was particularly intense on the beer brewed from Leonie. These notes are associated with increased astringency and in the expert tasting panels opinion might well impact on the drinkability.

6. Conclusions

Leonie

This was a small grained variety similar in size to Halcyon. Endosperm structure of this sample was quite poor but malting performance was at least as good as the control. It had the lowest malt β-glucan of the winter barleys, with proteolysis and amylolytic enzyme potential similar to the control. Pilot malting produced a malt very close to the target specification and brewhouse performance was good. Fermentation performance was as good as the Halcyon control. Beer flavour was significantly more malty than the control, but was also grainy and harsh.

Opal

This sample of Opal had a high total nitrogen and this variety may be a nitrogen scavenger. It had a large grain size and a reasonable endosperm structure. This sample was quite water sensitive. Despite the high TN, extract on micromalting was similar to the control, however protein modification was low. It also had high viscosity values and high scores in the fine/concentrated mash difference test, whilst friability and homogeneity were low. Pilot malting confirmed these results with the lowest coarse grind extract, highest β-glucan and very low friability. Brewhouse and fermentation performance were poor. The Opal beer had a sulphury character.

Vanessa

This was a very bold sample with a high TCW. Although at a reasonable nitrogen level, the endosperm of this sample was extremely steely (mealy score of 14% by Ltm). However, Vanessa had a significantly better extract than the Halcyon control. Proteolysis was satisfactory and viscosity was low. DP was low in the absence of GA. Pilot malting of Vanessa gave a malt with high extract, low viscosity and proteolysis similar to the control. There was no indication from the standard analyses that there would be any problems on brewing. However, brewhouse performance was very bad with turbid worts and high ΔP values on lautering. Fermentation performance was also poor and the final gravity at the end of fermentation was high. The low soluble nitrogen level in the wort might have been a contributory factor to the poor fermentation performance.

B. Spring Varieties

1. Barley Quality

Results of analyses for standard barley quality parameters are shown in **Table 9.** The nitrogen contents of this set of barleys were within specification for the production of lager malt. Both Cellar and County are a similar size to the Optic control whilst Pewter is slightly larger. Viability was good and all the samples recovered quickly from dormancy. The barleys were only moderately water sensitive.

Table 9 Barley Analyses

Variety	Cellar	County	Pewter	Optic
Barley Ref.No.	00/33	00/34	00/36	00/38
Moisture (%) (after drying)	11.4	11.9	11.1	11.2
Total Nitrogen (%)	1.77	1.76	1.82	1.71
TCW (g)	40.3	40.2	43.6	39.6
Sieve Analysis (g)				
> 2.8	73.5	67.1	82.4	67.1
2.5-2.8	18.7	20.9	12.3	21.5
2.2-2.5	6.0	8.4	3.9	8.0
<2.2	1.8	3.6	1.4	3.4
Viability (%)	99	98	97	98
Germinative Energy (%)	100	100	99	100
Water Sensitivity (%)	55	64	54	72

Endosperm quality was examined using the Light Transflectance Meter (see Annex 3). The LTM value is measured on 97 grains and gives a value (mV) for each grain. These results are grouped in 100 unit bands and values < 200 are classed as having mealy endosperm structure. The percentage grains in the sample having mealy endosperm was Cellar 100%, County 80%, Pewter 99%, Optic control 91%. Generally therefore, endosperm quality was very good although County was significantly less mealy than the rest (and therefore more steely which is an undesirable characteristic for malting barley).

2. Micro-malting

Each sample was micro-malted under two sets of conditions (with and without gibberellic acid) in order to compare malting performance **Table 10.**

Table 10. Malt Analyses small scale malting[1]

Parameter	**No added Gibberellic Acid**				**With Gibberellic Acid**			
Variety	Cellar	County	Pewter	Optic	Cellar	County	Pewter	Optic
Barley Ref. No.	00/33	00/34	00/36	00/38	00/33	00/34	00/36	00/38
Hot Water Extract (litre°/kg) fine grind	316	311	313	314	314	312	313	316
coarse grind	311	308	309	311	311	312	311	312
Total Soluble Nitrogen (%)	0.69	0.61	0.68	0.64	0.74	0.68	0.73	0.72
Total Nitrogen (%)	1.74	1.62	1.65	1.62	1.73	1.64	1.64	1.66
Soluble Nitrogen Ratio	40	38	41	40	43	41	45	43
Free Amino Nitrogen (mg/litre)	188	155	189	166	203	176	211	193
Fermentability (%)	83	83	83	83	83	82	82	82
Viscosity (mPa/s)	1.50	1.52	1.51	1.49	1.52	1.52	1.49	1.49
DP °IOB	130	139	111	123	145	145	103	113
DU	53	53	48	54	57	57	53	56
Wort Clarity	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear
Fine/ Concentrated Mash Difference	6	5	5	6	4	5	3	2
Viscosity of 70°Mash	4.19	4.08	4.35	4.34	4.16	4.15	4.28	4.28
Friability (%)	87	82	90	82	91	86	92	86
Homogeneity (%) [2]	95.9	96.4	99.1	96.3	97.1	99.2	99.0	98.8

[1] *Malting schedules: 7h wet/17h air/7h wet/17h air/1h wet + 4 days at 16°C +/- gibberellic acid (0.2ppm).*

[2] *from friability measurement*

Carbohydrate Modification

Cellar gave a good yield of extract, similar to the Optic control. Neither varieties showed much increase in extract when GA was added. The coarse grind extract (HWE_7) values for both County and Pewter were slightly lower than the control when gibberellic acid (GA) was not used. These differences were not apparent in the presence of GA, perhaps indicating greater sensitivity of these two varieties to this plant hormone. Fine/concentrated mash difference and 70°C mash viscosity values were low in all cases, which indicates that there should be no problems with carbohydrate hydrolysis.

Protein Modification

All the varieties showed a typical increase in protein modification when GA was used. County was the lowest protein modifier of the set, this was reflected in the lower soluble nitrogen ratio (SNR) and particularly in free amino nitrogen (FAN) values. Protein modification for Cellar, Pewter and Optic was similar.

Cell-wall Modification

Viscosity values for all the trial malts were low and similar to the Optic control. Friability for both Cellar and Pewter was higher than the control. One of the characteristics of Optic is to produce malts with a slightly low friability and County appears to have the same tendency. Collaborative micro-malting trials carried out by the IOB's English Micro-Malting Group (EMMG) show that this sample of County had high levels of β-glucan (approximately double that of the other barleys in this set); this may also be a reason for low friability.

Amylolytic Enzyme Potential

Both Cellar and County exhibited higher DP (principally β-amylase) than the control, whilst that of Pewter was slightly reduced. DU values (α-amylase), although slightly reduced with Pewter, were remarkably similar for all varieties.

3. Pilot Malting

Malting protocols

The spring samples were malted in the pilot plant and conditions were slightly varied to try and achieve the lager malt specification which is highlighted in **Table 12**. GA was not used, consistent with the requirement to produce a lager malt. Germination times were kept constant at four days for all the malts. The same kilning schedule was used for all the pilot malts.

Exact details of the malting conditions are given in the **Annex, Table 1 (b)**. The control of this sample set was Optic. Process data for each barley is given in **Table 11**.

Table 11. Pilot Malting, Process data

Variety	Cellar	County	Pewter	Optic
Barley Number	00/33	00/34	00/36	00/38
Malt Batch Number	857 P	855 P	856 P	854 P
Casting moisture(%)	47.5	47.2	47.8	46.5
Moisture at end of Germination (%)	45.0	44.4	45.0	43.5
Time to break point (hr)	18	19	19	19
Total kilning time (hr)	28	29	29	29

Pilot malting of these samples was carried out under very similar conditions. Malt yield was good for all the varieties at 85-86%"as is".

Malt Quality

Malt analysis data is given in **Table 12.**

Table 12. Pilot malting, spring malt analyses

ANALYSIS	TARGET SPECIFICATION	CELLAR	COUNTY	PEWTER	OPTIC
Barley number	**-**	00/33	00/34	00/36	00/38
Malt Batch number	**-**	857 P	855 P	856 P	854 P
Moisture (%)	**4.0-5.0**	4.6	4.3	4.4	4.8
HWE2 (l°/kg dry)	**310-315**	315	310	311	312
HWE7 (l°/kg dry)	**305-310**	311	306	309	309
F/C Diff	**5 max**	4	4	2	3
Colour (EBC)	**2.0-3.0**	2.6	2.2	2.9	2.2
DP (°lOB)	**75 min**	101	105	88	91
TN (%dry)	**1.60-1.80**	1.69	1.70	1.72	1.72
SNR (%)	**38-42**	38	32	40	34
FAN (mg/l)	**140-180**	133	111	150	111
Fermentability (%)	**74-78**	76	74	76	75
Friability (%)	**85 min**	92	93	96	89
Homogeneity (%)	**96 min**	97.3	98.8	99.3	97.7
Beta- Glucan (mg/l)	**100 max**	73	89	46	71
Viscosity mPas	**1.45-1.65**	1.52	1.53	1.52	1.53

All the barleys met the specification for extract, fine/coarse difference, colour, DP,TN, fermentability, friability, homogeneity and β-glucan. However only Cellar and Pewter did so for protein modification.
In particular, County gave a lower SNR value than the Optic control. This characteristic, was also noted by the English Micromalting Group (EMMG) during collaborative micromalting of these samples. The β-glucan content of all four malts met the target specification, with that of Pewter being particularly low. The friability of this sample was also very high, which could make the variety susceptible to damage during transport in the export malt market. Fermentability for County is slightly low.

It is recognised that variation in kilning and brewing conditions will affect the actual levels of DMS-p in the malt and wort, as well as the DMS in the final beer.

Table 13. Potential for DMS precursor

VARIETY	POTENTIAL DMS-precursor (taking Control as 100 units)
OPTIC	100
CELLAR	161
COUNTY	144
PEWTER	125

Foot note: DMS-p analysis was carried out on green malt at approximately 45% moisture

However, information on the capacity of a variety to produce DMS precursor is useful information for maltsters to have.
It was agreed at the Barley Committee, prior to this trial, that in order to eliminate variations due to kilning, DMS-p potential would be measured on green malt.
The results in Table 13 have been normalised relative to the Optic control. All the trial barleys showed greater potential to form DMS precursor than the control.

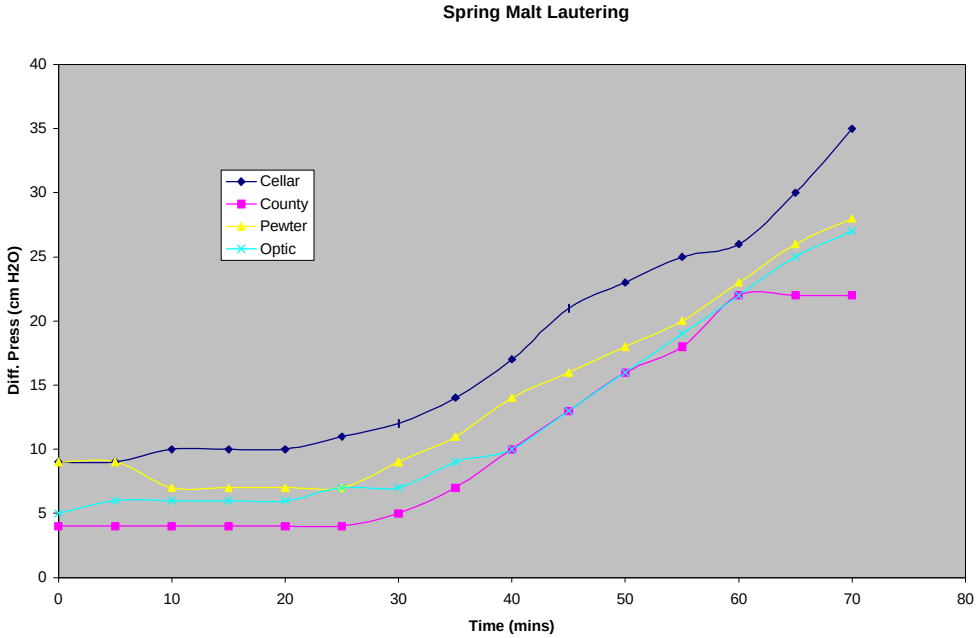
4. Pilot Brewing

The pilot malts were used for brewing in the BRI pilot brewery, using standard process conditions for BRI 11°Plato lagers. Details of these are given in the **ANNEX 2 .** Process data for each brew is given in **Table 14.**

Table 14. Pilot brewing, process data

Parameter	Cellar	County	Pewter	Optic
Brew No.	24/01	22/01	23/01	14/01
Barley No.	00/33	00/34	00/36	00/38
Malt No.	857 P	855 P	856 P	854 P
Lauter time (min)	83	81	81	83
Gravity of last runnings (°gravity)	1002.9	N/A	1005.6	N/A
Wort clarity	Good	Good	Good	Good
Trub settling time (min)	30	30	30	30
Final wort gravity pre-fermentation	1044.3	1044.2	1044.0	1044.0
Total volume wort (litres)	101.5	101.5	101.5	96.5
Yeast viability at harvest (%)	87	91	85	91
Final gravity (°)	1004.6	1005.1	1005.8	1005.2
Gravity drop (° of gravity)	39.7	39.1	38.2	38.8

Fig 7



All the malts performed well in the brewhouse.The ease of wort separation was assessed by measuring differential pressure (ΔP) across the lauter tun bed during wort run-off, see **Fig 7**.

All three trial varieties exhibited good run-off characteristics similar to the control (see attached graphs). Cellar showed the highest Delta P of the set but this was not outside the expected operating range. Pilot lautering performance was therefore ranked: County/Optic>Pewter>Cellar, but it should be stressed again that all of these malts lautered well.

Pilot brewery extracts were broadly in line with the laboratory predictions and were ranked:
Cellar/County/Optic>Pewter
During fermentation the gravity drop was good for all the beers **(see Fig 8 Fermentation Performance)** but yeast viability at the end of fermentation was rather low for Cellar and Pewter.

Wort analyses are shown in **Table 15.**
Colour, pH, OG, BU and nitrogen analyses are all within the normal ranges. Fermentability was good in all cases.

Table 15. Wort Analyses

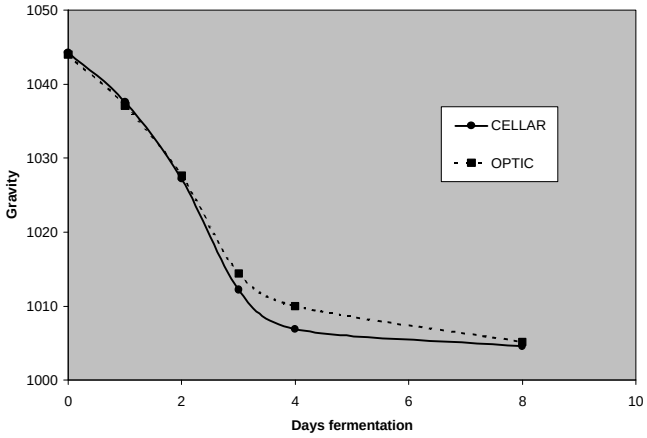
Parameter	Cellar	County	Pewter	Optic
Brew No.	24/01	22/01	23/01	14/01
Barley No.	00/33	00/34	00/36	00/38
pH	5.70	5.81	5.63	5.56
Colour (°EBC)	10.6	10.9	12.9	9.9
Original Gravity °	43.7	43.5	43.6	43.8
Bitterness (BU)	32	33	32	29
Free Amino Nitrogen (mg/litre)	172	146	189	144
Total Soluble Nitrogen (mg/litre)	812	731	854	719
Fermentability (%)	74	73	74	72

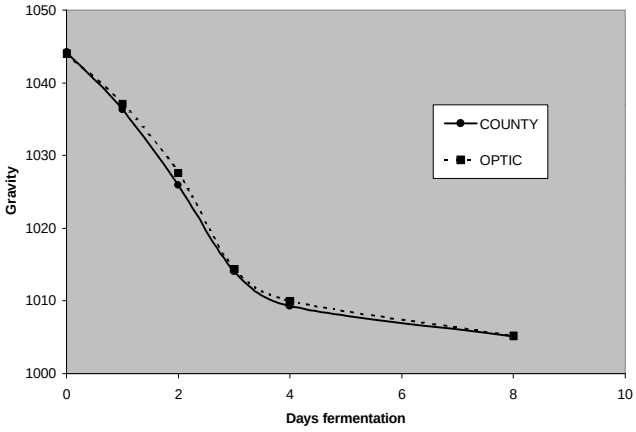
Fermentation Performance

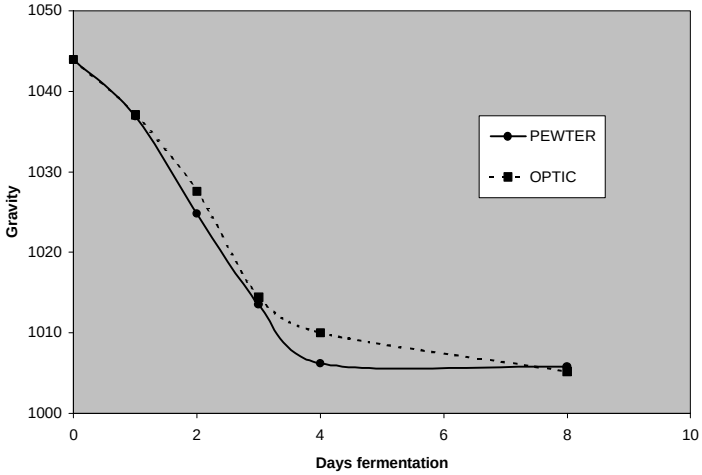
Fermentation profiles for the trial beers are shown in **Figure 8**. Results for each variety are plotted separately against the Optic control.

Figure 8. Fermentation profiles for beers

Each variety is plotted separately against the control







In each case the trial beers attenuated similarly to the control by the end of the standard fermetation period, but both Cellar and particularly Pewter had slower fermentation rates towards the end of this process.

5. Beer Quality and Flavour

Results for standard beer quality analyses are shown in **Table 16.**

Table 16. Pilot brewing, beer analyses, standard parameters

Parameter	Cellar	County	Pewter	Optic
Brew No.	24/01	22/01	23/01	14/01
Barley No.	00/33	00/34	00/36	00/38
pH	4.11	4.00	4.08	4.16
Colour (°EBC)	7.2	7.8	8.6	8.0
Present Gravity (°)	3.70	5.50	3.96	5.75
Attenuation limit (°)	4.14	5.41	4.29	6.10
Head Retention Value (Nibem) (sec)	74, 148, 223	76,148, 215	74,145, 214	81,155, 231
Bitterness (BU)	19	20	21	23
Free Amino Nitrogen (mg/litre)	44.2	30.4	52.6	37.0
Total Soluble Nitrogen (mg/litre)	319	317	373	361
Ethanol (% v/v)	5.02	5.02	5.22	5.17

All these parameters are within specification and present no anomalies. Beer PG values are close to or even slightly below the attenuation limit values, indicating complete fermentation in all cases. Beer alcohol values are all as expected.

Beer Flavour

The aroma and taste of each beer was assessed by BRI's trained flavour profile panel. These results are presented as "spider diagrams" in **Figures 9-12**

Figure 9. Aroma and Taste scores for Cellar beer

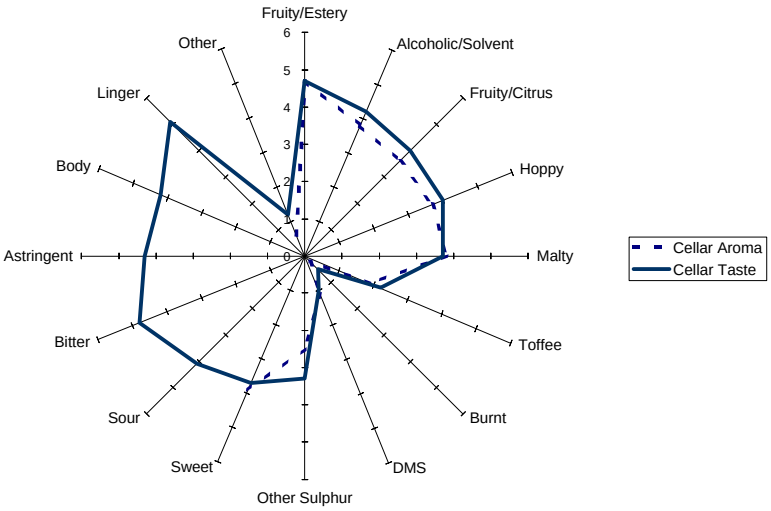


Figure 10. Aroma and Taste scores for County

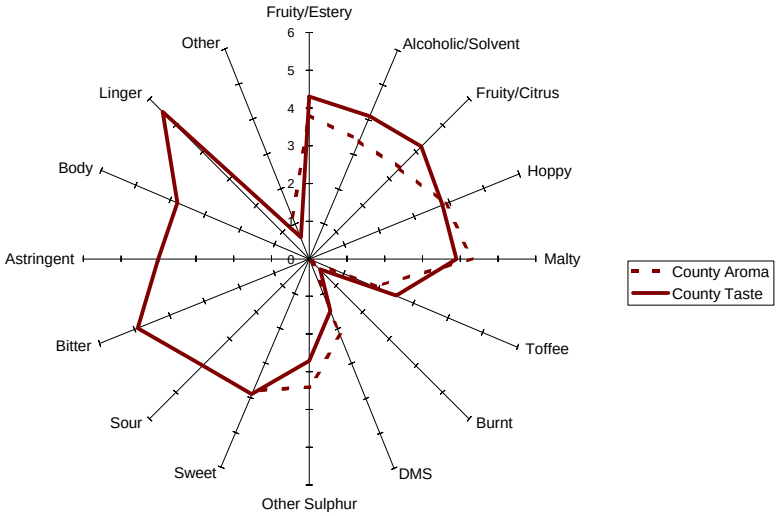


Figure 11. Aroma and Taste scores for Pewter beer

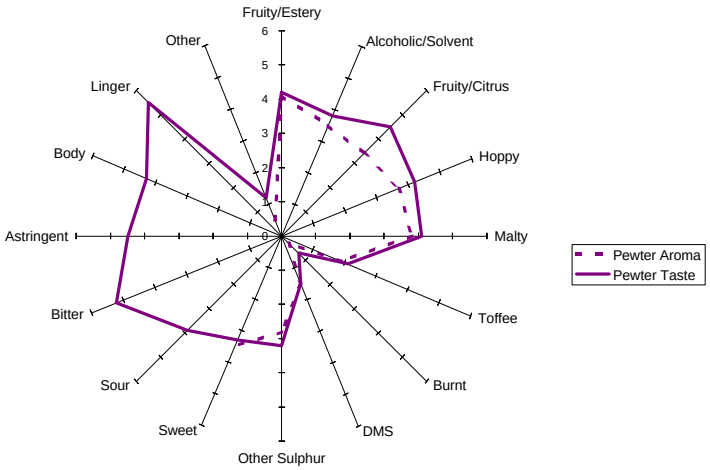
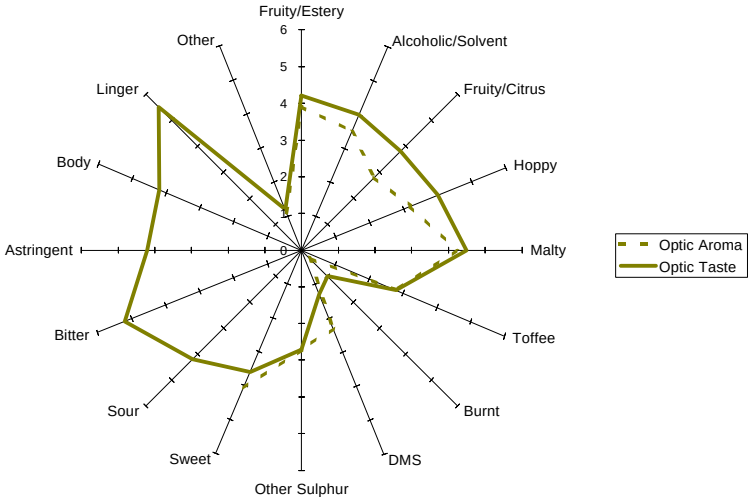


Figure 12. Aroma and Taste scores for Optic beer



Essentially all the beers were similar in character but some differences can be highlighted:

Significant differences on taste with respect to Optic

- Cellar was significantly more estery than Optic.
- Optic was significantly more toffee than County, Cellar and Pewter.
- Cellar had significantly less DMS than Optic.
- Optic had significantly more sweetness than Pewter.

The beers brewed from the spring malt varieties all exhibited a grainy / husky note to a greater or lesser extent but in no case did it dominate the flavour.

6. Conclusions

Cellar

This barley was of moderate grain size with good germinative characteristics. There was no significant dormancy and water sensitivity was moderate. Endosperm structure was very good (100%) mealy. Micromalting extracts and protein modification, were similar to the Optic control. Malt friability was high with good values for DP. Cellar met all but the FAN pilot malt target specifications and performed well in the brewhouse with no wort separation or fermentation problems. Beer flavour was judged to be more estery than the control but beer quality was sound.

County

Similar size grain to Optic with a virtually identical corn size distribution. Germinative characteristics were good and there was no significant dormancy, water sensitivity was moderate. Endosperm quality was the least good of the set but the mealiness score was still 80%. Extract values were slightly lower than the control, particularly when GA was not used. Although viscosity values were low, β-glucan levels established in the EMMG micromalting trials were high. Friability was on the low side, similar to the Optic control. DP values were similar to Cellar. Pilot malts were below specification for protein modification, similar to the response of Optic but with slightly lower extract. Although in specification, β-glucan was again high. Nonetheless, brewhouse and fermentation performance was good and there were no obvious flavour taints.

Pewter

This variety was the largest grained in this trial with nearly 95% of the sample comprising corns > 2.5mm. Germinative characteristics were good, there was no significant dormancy and water sensitivity was moderate. Endosperm quality was very good (mealiness score was 99%). Extracts were similar to the control as were some of the indicators for protein modification, although Pewter did produce high FAN values. Viscosity was low and friability high indicating good cell-wall breakdown characteristics. Comments during EMMG collaborative trials suggest that this variety is prone to grain splitting. DP and DU values were slightly depressed, but pilot malting did hit all the target specifications. Brewhouse and fermentation performance was good and there were no obvious flavour taints.

Annex

Table 1 (a). Pilot Malting Conditions for Winter varieties

STEEPING:

TIME (h)	**LEONIE**	**OPAL**	**VANESSA**	**HALCYON**
1st steep	8	8	8	8
air-rest	14	14	14	14
2nd steep	10	10	10	10
air-rest	10	10	10	10
3rd steep	4	6	6	6
air-rest	2	2	2	2
TOTAL	48	50	50	50
STEEP TEMP (°C)	17	17	17	17
CAST MOISTURE (%)	46.9	45.0	46.0	45.3

GERMINATION:

GA	NONE USED			
4 DAYS	1 @ 15°C	1 @ 16°C	1 @ 17°C	1 @ 18°C

KILNING:

MEAN CONDITIONS	
Break time (h)	16
Post break air recirculation employed	
Total time (h)	27
Max curing temp (°C)	85

Annex

Table 1(b). Pilot Malting Conditions for Spring varieties

STEEPING:

TIME (h)	**CELLAR**	**COUNTY**	**PEWTER**	**OPTIC**
1st steep	8	8	8	8
air-rest	14	14	14	14
2nd steep	10	10	10	10
air-rest	10	10	10	10
3rd steep	2	2	2	2
air-rest	2	2	2	2
TOTAL	46	46	46	46
STEEP TEMP (°C)	17	17	17	17
CAST MOISTURE (%)	47.5	47.2	47.8	46.5

GERMINATION:

GA	NONE USED			
4 DAYS	1 @ 15°C	1 @ 16°C	1 @ 17°C	1 @ 18°C

KILNING:

MEAN CONDITIONS	
Break time (h)	19
Post break air recirculation employed	
Total time (h)	29
Max curing temp (°C)	85

Annex 2

Pilot Brewing, Process Conditions, 11°P Lager

Brewing Stage	Conditions
Grist:	13.5 kg test malt 1.6 kg Cara malt 0.5 kg Flour liquor/grist ratio 3:1
Mashing	Infusion mash at 64°C for 60 mins. Sparge temperature 78°C
Kettle Boil	Boil time 90 mins Hop grist; 12.5 g $HOPCO_2N$ at t=0 20g Saaz Pellets at t=80 1.5 kg Fermentose syrup (853)
Fermentation	12°C for 6 days or until PG < 1010° gravity Yeast strain BRYC 32
Maturation	3 days at 13° 1-2 days cold rest at 3°C minimum of 7 days cold maturation at 0°C
Packaging	DE filter sheets, type XE 200 275 ml bottles
Pasteurisation	15 min at 60°

Annex 3

LTM Results for:
Leonie, Opal, Vanessa and Halcyon

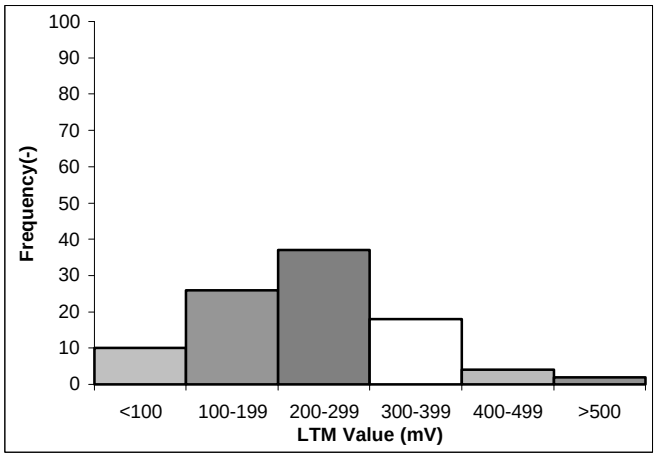
Cellar, County, Pewter and Optic
(see following eight pages)

BRI rapid LTM measurement

Sample Name:	**Leonie**	Date:	**22/02/01**
Sample number:	**00/6**	Hour:	**11:36 AM**
Stage:	**Barley**		

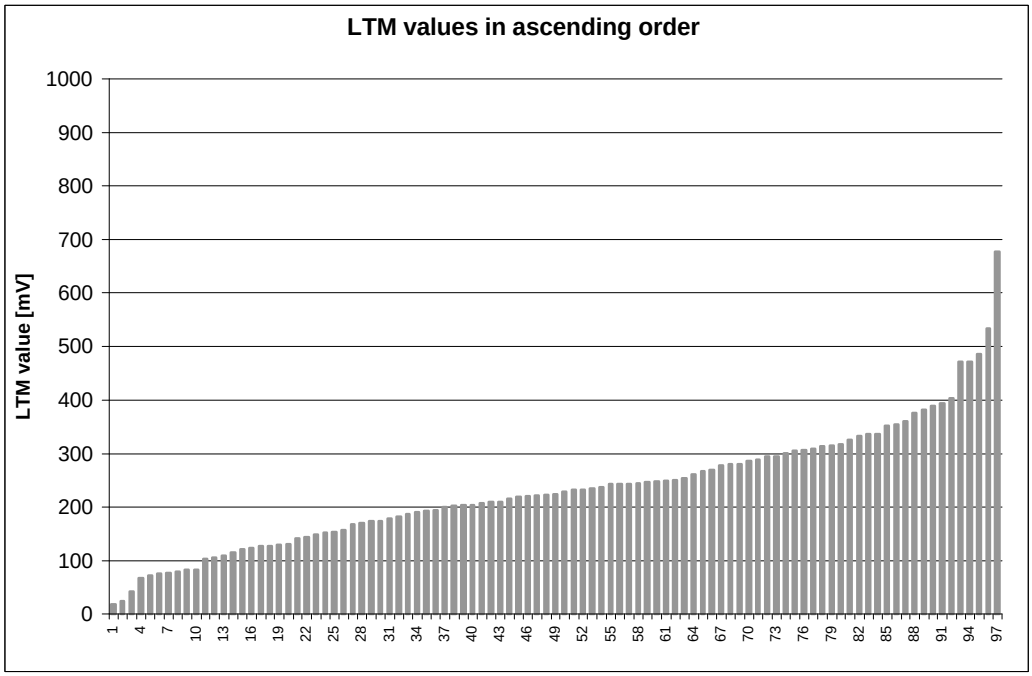
Filter 1: 1002 Filter 2: 102 Filter 3: 2

Distribution of grains with different endosperm structure



LTM Values	Count	Ratio
<100	10	10
100-199	26	27
200-299	37	38
300-399	18	19
400-499	4	4
>500	2	2
Total	97	100

Percentage of mealy grains: 37%



BRI rapid LTM measurement

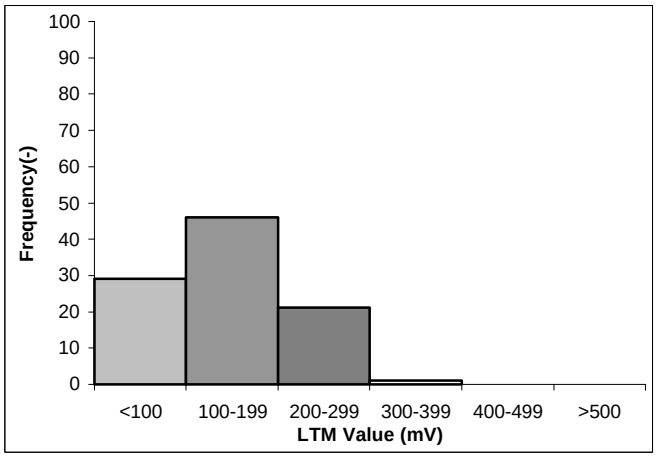
Sample Name: **Opal** Date: **22/02/01**

Sample number: **00/7** Hour: **11:50 AM**

Stage: **Barley**

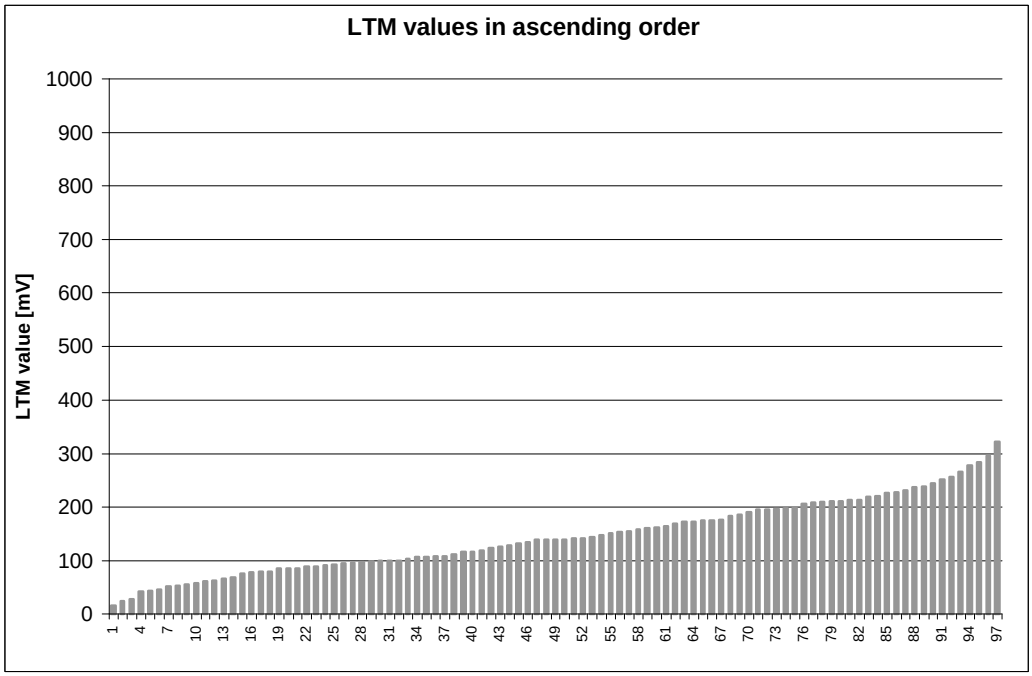
Filter 1: 1001 Filter 2: 105 Filter 3: 1

Distribution of grains with different endosperm structure



LTM Values	Count	Ratio
<100	29	30
100-199	46	47
200-299	21	22
300-399	1	1
400-499	0	0
>500	0	0
Total	97	100

Percentage of mealy grains: 76%

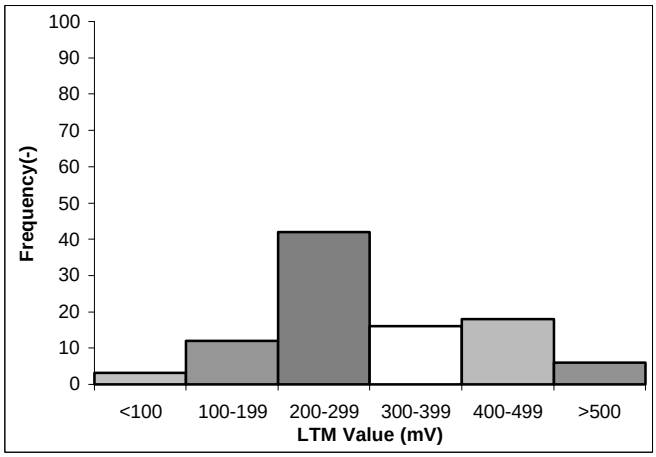


BRI rapid LTM measurement

Sample Name:	**Vanessa**	Date:	**22/02/01**
Sample number:	**00/31**	Hour:	**12:03 PM**
Stage:	**Barley**		

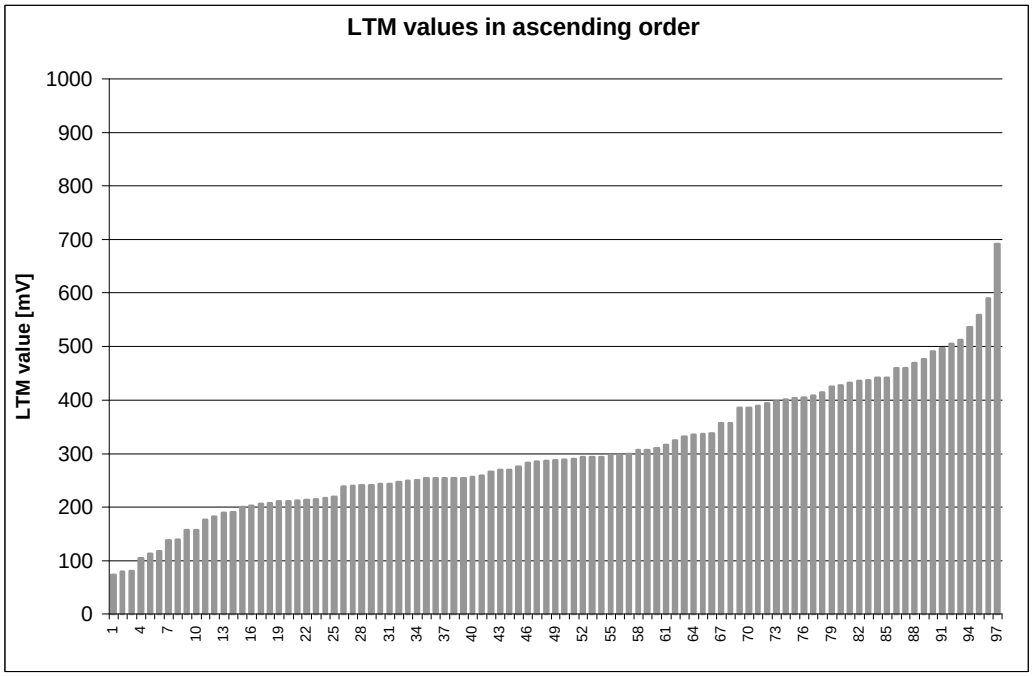
Filter 1: 1001 Filter 2: 104 Filter 3: 1

Distribution of grains with different endosperm structure



LTM Values	Count	Ratio
<100	3	3
100-199	12	12
200-299	42	43
300-399	16	16
400-499	18	19
>500	6	6
Total	97	100

Percentage of mealy grains: 14%

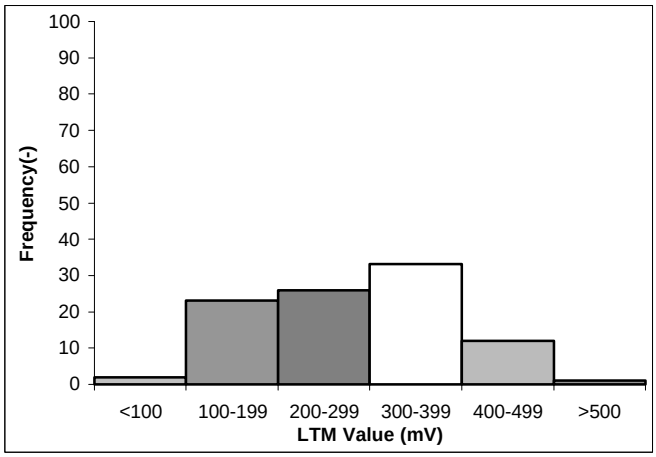


BRI rapid LTM measurement

Sample Name:	**Halcyon**	Date:	**22/02/01**
Sample number:	**00/9**	Hour:	**12:15 PM**
Stage:	**Barley**		

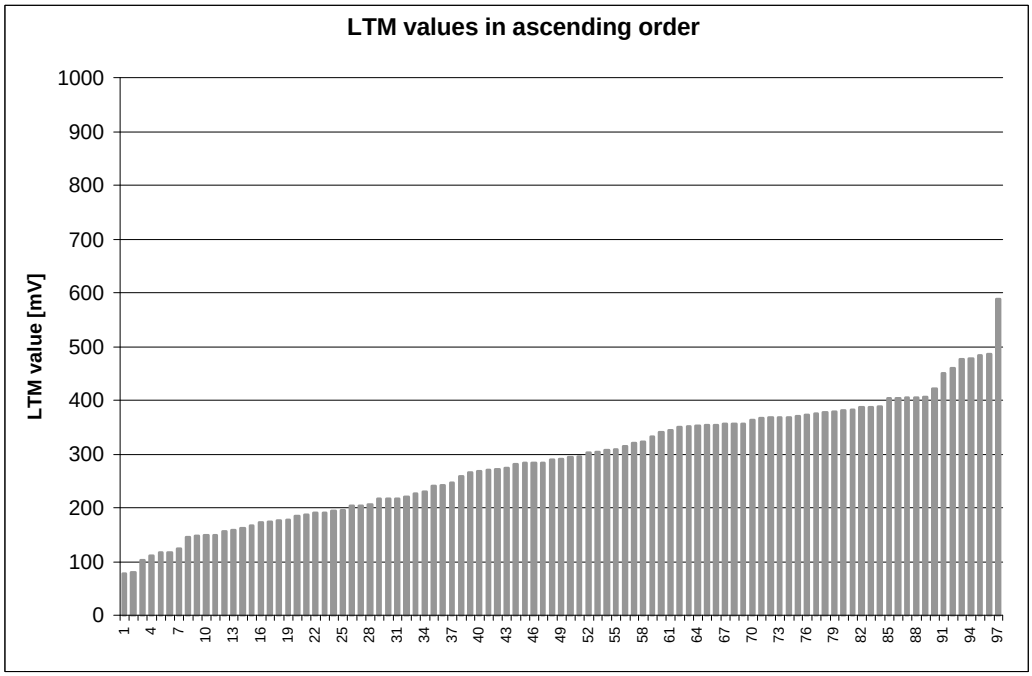
Filter 1: 994 Filter 2: 102 Filter 3: 1

Distribution of grains with different endosperm structure



LTM Values	Count	Ratio
<100	2	2
100-199	23	24
200-299	26	27
300-399	33	34
400-499	12	12
>500	1	1
Total	97	100

Percentage of mealy grains: 26%

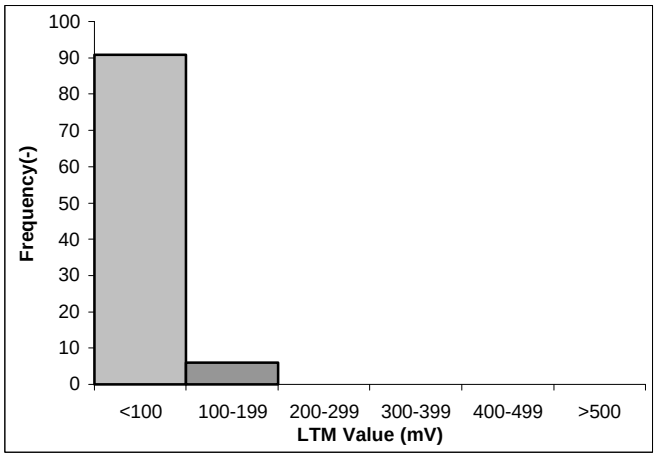


BRI rapid LTM measurement

Sample Name:	**Cellar**	Date:	**22/02/01**
Sample number:	**00/33**	Hour:	**2:13 PM**
Stage:	**Barley**		

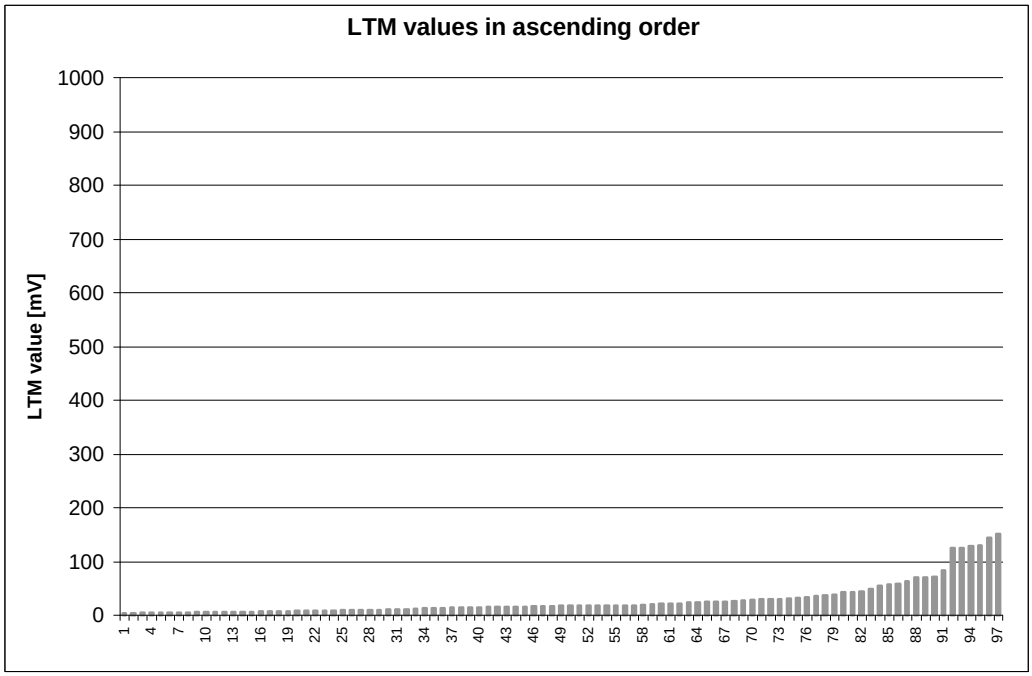
Filter 1: 1001 Filter 2: 102 Filter 3: 1

Distribution of grains with different endosperm structure



LTM Values	Count	Ratio
<100	91	94
100-199	6	6
200-299	0	0
300-399	0	0
400-499	0	0
>500	0	0
Total	97	100

Percentage of mealy grains: 100%

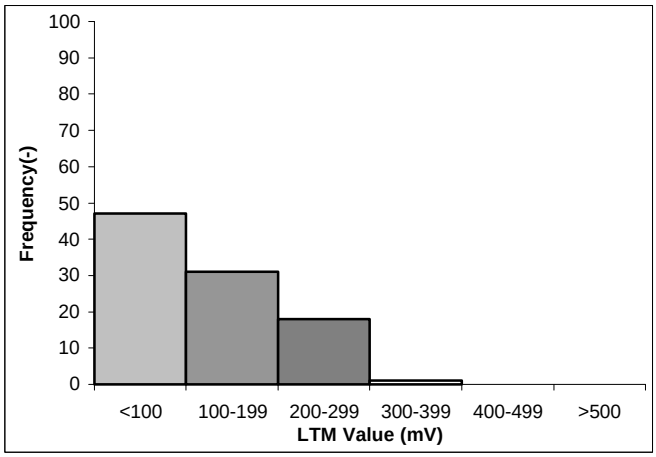


BRI rapid LTM measurement

Sample Name:	**County**	Date:	**22/02/01**
Sample number:	**00/34**	Hour:	**2:29 PM**
Stage:	**Barley**		

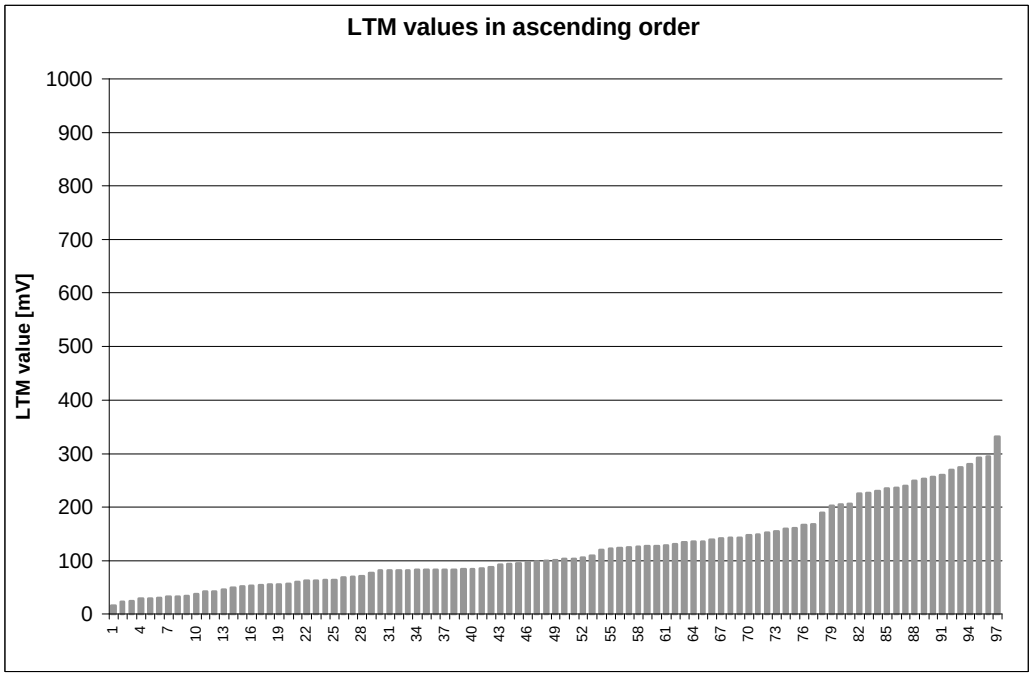
Filter 1: 994 Filter 2: 105 Filter 3: 1

Distribution of grains with different endosperm structure



LTM Values	Count	Ratio
<100	47	48
100-199	31	32
200-299	18	19
300-399	1	1
400-499	0	0
>500	0	0
Total	97	100

Percentage of mealy grains: 80%

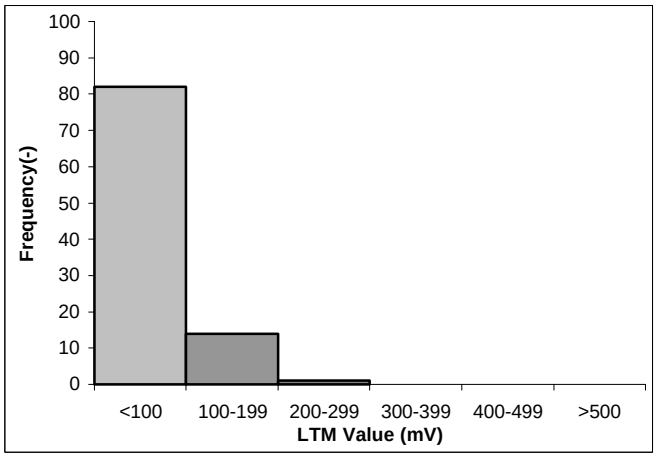


BRI rapid LTM measurement

Sample Name:	**Pewter**	Date:	**22/02/01**
Sample number:	**00/36**	Hour:	**3:05 PM**
Stage:	**Barley**		

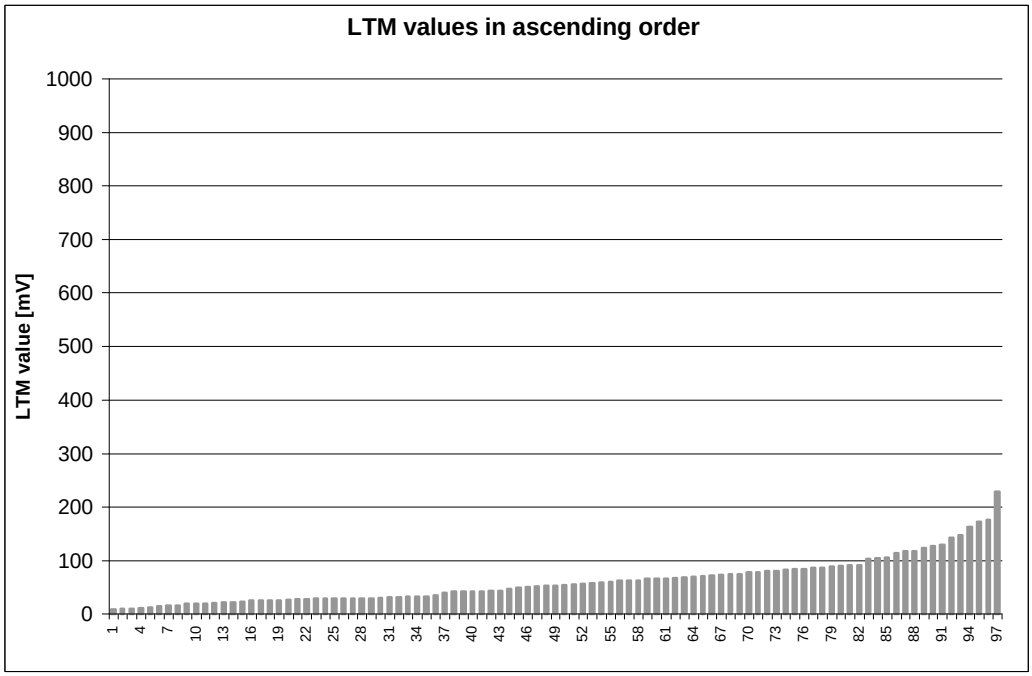
Filter 1: 1002 Filter 2: 104 Filter 3: 1

Distribution of grains with different endosperm structure



LTM Values	Count	Ratio
<100	82	85
100-199	14	14
200-299	1	1
300-399	0	0
400-499	0	0
>500	0	0
Total	97	100

Percentage of mealy grains: 99%

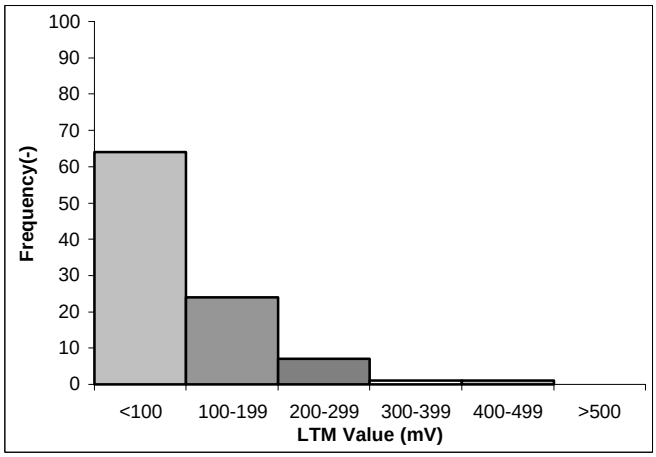


BRI rapid LTM measurement

Sample Name:	**Optic**	Date:	**22/02/01**
Sample number:	**00/38**	Hour:	**3:18 PM**
Stage:	**Barley**		

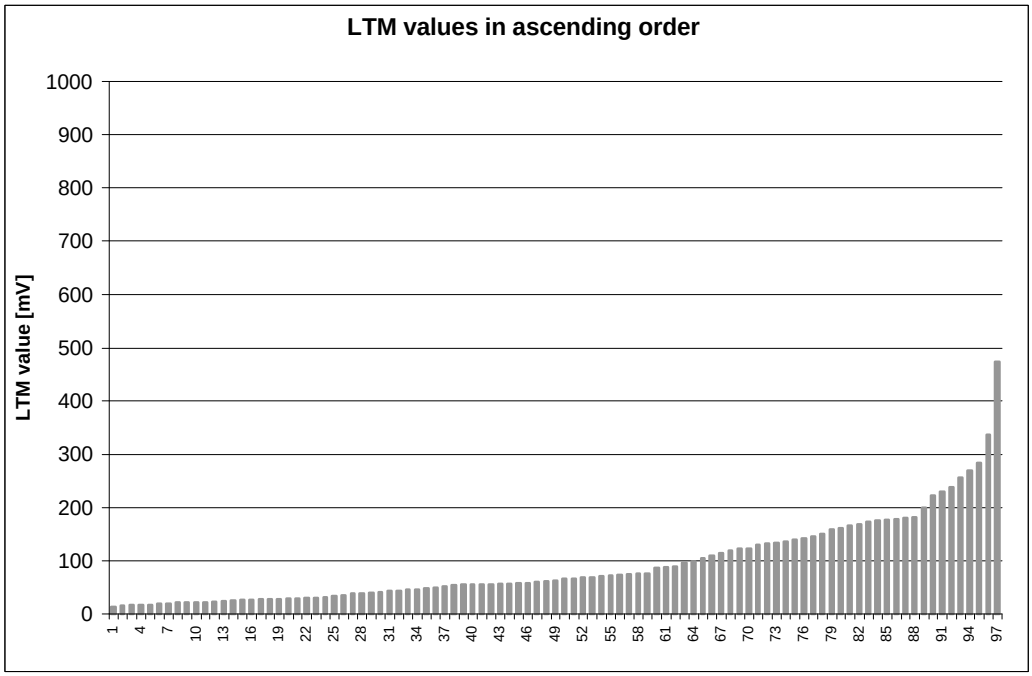
Filter 1: 1001 Filter 2: 101 Filter 3: 1

Distribution of grains with different endosperm structure



LTM Values	Count	Ratio
<100	64	66
100-199	24	25
200-299	7	7
300-399	1	1
400-499	1	1
>500	0	0
Total	97	100

Percentage of mealy grains: 91%



Annex 4

IOB Approved Varieties 2001-2002

SOUTH	NORTH
Winter:	Winter:
Regina	Regina
Fanfare	(Pearl)*
Pearl	
(Leonie)	
Spring:	Spring:
Optic	Optic
Chariot	Chariot
(Decanter)	Prisma
(Tavern)	Chalice
(Cellar)	Decanter
	(Cellar)
	(Chime)

( ) = Provisional 1
( )* = Provisional 2