PROJECT REPORT No: 287

MALTING AND BREWING CHARACTERISTICS OF NEW MALTING BARLEY VARIETIES (WINTER - DIAMOND; SPRING - SPIRE) (2001/2002 TRIALS)

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MALTING AND BREWING CHARACTERISTICS OF NEW MALTING BARLEY VARIETIES (WINTER – DIAMOND; SPRING - SPIRE) (2001/2002 TRIALS)

by

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1. EXECUTIVE SUMMARY

1.1 Samples of one new winter (Diamond) and one new spring barley (Spire) were assessed for malting and brewing quality. Each variety was compared with a control grown at the same site. 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.

1.2 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.

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

1.4 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).

1.5 Winter Barley

Diamond appears to be a good variety with high extract, low β-glucan and a ready ability to form soluble nitrogen. This combination may mean that potential to form colour could be high. On pilot malting, the trial variety performed well in the brewhouse. There were no significant differences in either lautering or fermentation performance when compared to the relevant control. The lager beers produced were of sound quality and flavour, typical of their type. This variety produces a consistently low DP, which may compromise its suitability for some commercial applications.

At the Malting Barley Committee (30th May) Diamond was awarded Provisional 1 status on the IOB Approved Variety List for Harvest 2003.

1.6 Spring Barley

Spire was not better overall than the Optic control; extract in particular was significantly lower. Due to optimisation of the pilot malting process the trial variety performed well in the brewhouse. There were no significant differences in either lautering or fermentation performance when compared to the relevant control. The lager beers produced were of sound quality and flavour, typical of their type.

Spire did not progress onto the IOB Approved Variety List.

A copy of the current IOB Approved Variety List for Harvest 2003 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 2001 crop were:
Winter **Diamond**
Spring **Spire**

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

Samples were grown at two ADAS sites for each group (**winters:** High Mowthorpe, Yorks and Cholsey, Oxon; **springs:**Puddletown, Dorset and Great Limber, Lincs.) The samples used for this project were selected on the basis of suitable viability and nitrogen content as below.

BRI Reference	Type	Variety	Site
01/6	Winter	Diamond	Oxon
01/5	Winter	Pearl (control)	Oxon

BRI Reference	Type	Variety	Site
01/14	Spring	Spire	Lincs
01/12	Spring	Optic (control)	Lincs

RESULTS OF MALTING AND BREWING TRIALS

A. Winter Variety

1. Barley Quality

Results of analyses for standard barley quality parameters are shown in **Table 1.** The nitrogen content of Diamond was significantly lower than that of the Pearl control, whilst grain size, as indicated by thousand corn weight, was smaller. However both samples were bold with a low percentage of screenings and of good viability. The barleys were not dormant at the time of malting and Diamond exhibited less water sensitivity than the control.

Table1. Barley Analyses

Variety	Diamond	Pearl (control)
Barley Ref.No.	01/6	01/5
Moisture (%) (after drying)	11.6	11.6
Total Nitrogen (%)	1.51	1.67
TCW (g)	39.9	47.5
Sieve Analysis (g)		
> 2.8	85.0	92.0
2.5-2.8	11.4	6.2
2.2-2.5	2.5	1.2
<2.2	1.1	0.6
Viability (%)	99	98
Germinative Energy (%)	98	99
Water Sensitivity (%)	85	45

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 Diamond 88% and Pearl 98%. The mealiness score of the control is particularly high, but both samples show that the malting quality of these samples is in the range 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	**Diamond**	**Pearl**	**Diamond**	**Pearl**
Barley Ref. No.	01/6	01/5	01/6	01/5
Hot Water Extract (litre°/kg) coarse grind	315	306	317	310
Total Soluble Nitrogen (%)	0.61	0.60	0.67	0.64
Total Nitrogen (%)	1.45	1.63	1.45	1.70
Soluble Nitrogen Ratio	42	37	46	41
Free Amino Nitrogen (mg/litre)	144	129	165	150
Fermentability (%)	77	75	82	76
Viscosity (mPa.s)	1.50	1.56	1.48	1.55
DP (°IOB)	63	116	70	132
DU	37	44	52	52
Wort Clarity	Clear	Clear	Clear	Clear
Friability (%)	97	88	98	93
Homogeneity (%) [2]	99.5	98.0	99.7	99.4

[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

The Diamond malt produced much higher extract than the Pearl control. In part this would be expected because of the difference in nitrogen content, however when the difference is taken into account, Diamond extract was still significantly higher. The use of gibberellic acid (GA) had only a slight effect on Diamond extract.

Protein Modification

Diamond exhibited easy protein modification giving total soluble levels (TSN) similar to the Pearl control but from a much lower nitrogen starting point. Consequently, soluble nitrogen ratio (SNR) was significantly higher than the control. The same trends were apparent when GA was used during malting. Free amino nitrogen values (FAN) were also much higher than the control when the low Diamond barley TN was taken into account.

Cell-wall Modification

The trial variety was better than the control in all respects for those markers indicative of good cell-wall modification. Viscosity values of Diamond extract were low and friability of the Diamond malt, significantly higher.

Amylolytic Enzyme Potential

The variety Diamond has a low potential to form diastatic power (DP) which is principally a measure of β-amylase. This was confirmed by the micro-malting results, which show DP values about half that of the Pearl control, a conclusion that did not alter when GA was used. It is interesting to note that dextrinising units (DU), a measure of α-amylase activity in the Diamond malt was similar to the control.

3. Pilot Malting

Malting protocols
The winter samples were malted in the pilot plant to try and achieve the lager malt specification, which is highlighted in **Table 4**. GA was not used, consistent with the requirement to produce lager malt. Germination times were kept constant at five days for both the malts.
The same kilning schedule was used for all the pilot malts but variations in the pre-break period (kiln load moisture) meant that total kilning time varied between 26 and 28 hours.

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

Process data for each barley is given in **Table 3**.

Table 3. Pilot Malting, Process data

Variety	Diamond	Pearl
Barley Number	01/5	01/6
Malt Batch Number	888 P	887 P
Casting moisture(%)	46.5	45.7
Moisture at end of Germination (%)	43.6	42.4
Time to break point (hr)	18	15.5
Total kilning time (hr)	28	25.5

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

Malt Quality

Malt analysis data is given in **Table 4.**
In general, pilot malting of the winter trial and control confirmed the conclusions derived from micro-malting. Most significantly, Diamond produced better extract and lower DP than the Pearl and also showed very low β-glucan levels compared with the control. This confirms that cell wall modification in Diamond was good and low β-glucan levels were also seen in the collated English mico-malting data (EMMG) for this variety.
Both the trial and control pilot malts met the target specification closely enough to allow brewing.

Table 4. Pilot malting, winter malt analyses

ANALYSIS	TARGET SPECIFICATION	Diamond	Pearl
Barley number	**-**	01/6	01/5
Malt Batch number	**-**	888 P	887 P
Moisture (%)	**4.0-5.0**	5.0	4.5
HWE2 (l°/kg dry)	**310-315**	313	306
HWE7 (l°/kg dry)	**305-310**	313	304
F/C Diff	**5 max**	0	2
Colour (EBC)	**2.0-3.0**	2.6	2.6
DP (°IOB)	**75 min**	47	94
TN (%dry)	**1.60-1.80**	1.54	1.57
SNR (%)	**38-42**	36	38
FAN (mg/l)	**140-180**	120	115
Fermentability (%)	**74-78**	76	73
Friability (%)	**85 min**	97	94
Homogeneity (%)	**96 min**	99.4	99.3
Beta- Glucan (mg/l)	**100 max**	17	72
Viscosity mPas	**1.45-1.65**	1.50	1.51

4. Pilot Brewing

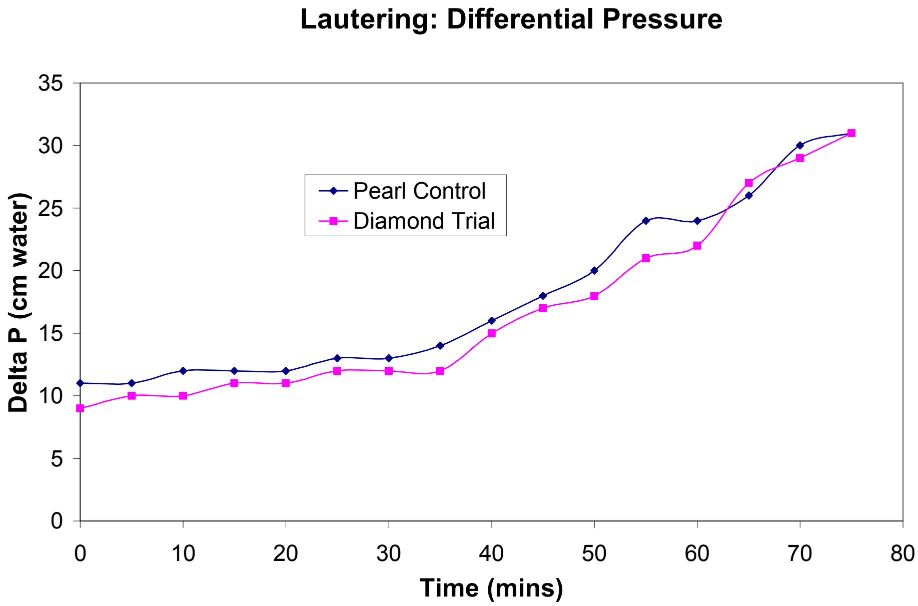
The pilot malts were used for brewing in the BRI pilot brewery, using standard process conditions for BRI 11°Plato lagers. Details of these are given in the **ANNEX 2.** Process data for each brew is given in **Table 5.**

Table 5. Pilot brewing, process data

Parameter	Diamond	Pearl
Brew No.	14/02	13/02
Barley No.	01/6	01/5
Malt No.	888 P	887 P
Lauter time (min)	83	82
Gravity of last runnings (°gravity)	1004.0	1008.2
Wort clarity	v.good	v. good
Trub settling time (min)	30	30
Final wort gravity pre-fermentation (°gravity)	1043.5	1044.1
Total volume wort (litres)	100	94
Yeast viability at harvest (%)	81	90
Final gravity (°gravity)	1005.5	1005.8
Gravity drop (° of gravity)	38.0	38.3

There were no significant differences in the lautering performance which was assessed by measuring differential pressure (ΔP) across the lauter tun bed during wort run-off (see **Fig 1**). Brew-house performance was satisfactory with the Diamond malt producing particularly bright wort.
The only significant difference between the control and trial data shown in Table 6 is the viability of the yeast at the end of fermentation. There is no indication that this difference could be traceable to any effect of barley variety or malt quality.

Fig 1:



Pilot brewery extract was ranked as :
Diamond > Pearl
This is in line with the malt analysis data for Diamond, which shows a higher extract value than the control.

Wort analyses are shown in **Table 6.**

Table 6. Wort Analyses

Parameter	Diamond	Pearl
Brew No.	14/02	13/02
Barley No.	01/6	01/5
pH	5.34	5.44
Colour (°EBC)	12.8	12.9
Original Gravity °	44.1	44.1
Bitterness (BU)	33	34
Free Amino Nitrogen (mg/litre)	134	134
Total Soluble Nitrogen (mg/litre)	751	801
Fermentability (%)	73	71

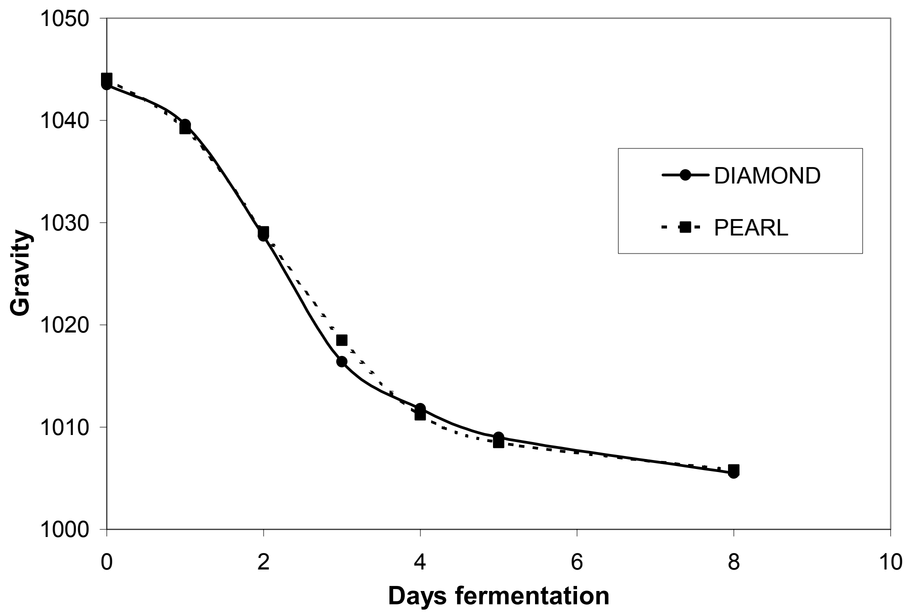
The pitching wort data shown does not indicate any gross differences between the Diamond trial or the Pearl control. Wort original gravity in the control is slightly low.

Fermentation Performance

The fermentation profiles for the trial and control beer are shown in **Figure 2**. There was no significant difference between them.

Figure 2. Fermentation profiles for Diamond beer

Each variety is plotted separately against the control.



5. Beer Quality and Flavour

Results for standard beer quality analyses are shown in **Table 7.**

Table 7. Pilot brewing, beer analyses, standard parameters

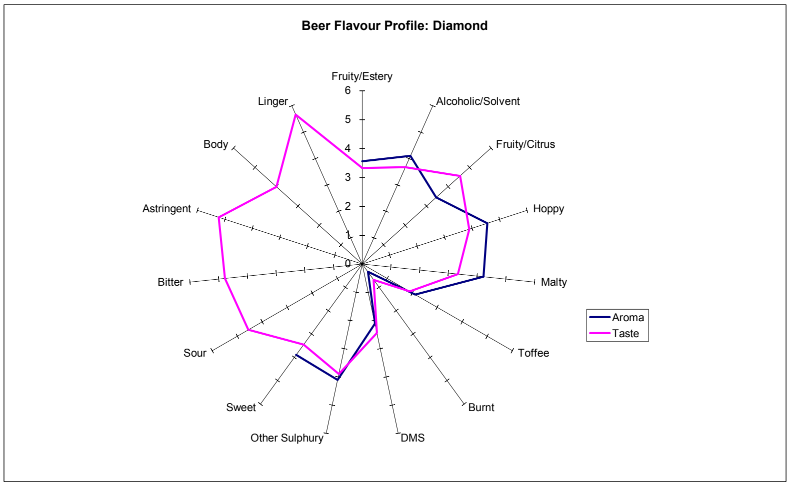
Parameter	Diamond	Pearl
Brew No.	14/02	13/02
Barley No.	01/6	01/5
pH	3.99	4.06
Colour (°EBC)	8.6	9.0
Present Gravity (°)	4.96	5.29
Attenuation limit (°)	5.87	6.63
Head Retention Value (Nibem) (sec)	75,150, 224	65,128, 190
Bitterness (BU)	19	20
Free Amino Nitrogen (mg/litre)	25.3	32.7
Total Soluble Nitrogen (mg/litre)	408	423
Ethanol (% v/v)	4.87	4.90

The values for both the trial and the control are all within specification.
The beer brewed from the Diamond malt showed slightly superior foam quality (HRV) and soluble nitrogen is in line with pitching wort values. Present gravity and attenuation limit values show that the trial beer fermented at least as well as the control and ethanol production was the same.

Beer Flavour

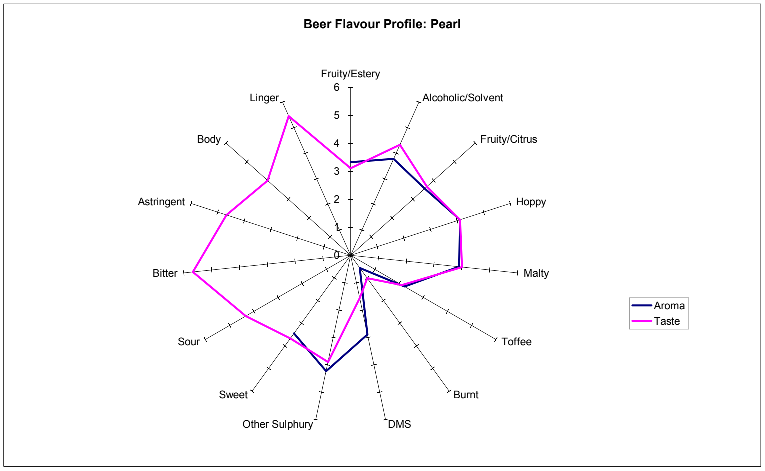
The aroma and taste of each beer was assessed by BRI's trained flavour profile panel. These results are presented as "spider diagrams" in **Figures 3 & 4**

Figure 3. Aroma and Taste scores for Diamond beer



There were no beer flavour taints attributable to either the Diamond trial or the Pearl control. The Diamond beer had significantly more citrus and DMS character and was perceived as less bitter and warming than the control beer.

Figure 4. Aroma and Taste scores for Pearl beer



6. Conclusions

Diamond

Smaller corn size than Pearl but the sample had a good corn size distribution and good viability. Germination was good and water sensitivity low. On micro-malting, the Diamond malts were characterised by high extract, producing high levels of soluble nitrogen with very low β- glucan content. However DP values were very low (about half that of Pearl). Diamond DP remained low even in the presence of GA. In general, the malting characteristics of the trial variety were confirmed on the pilot scale where Diamond gave high extract and friability with very low β-glucan compared to the Pearl control. However DP was again very low (about half that of the control). The malt of this trial variety performed well in the brewhouse. There were no significant differences in either lautering or fermentation performance when compared to the Pearl control. Tasting of the trial beer revealed no beer flavour taints attributable to the variety.

B. Spring Varieties

1. Barley Quality

Results of analyses for standard barley quality parameters are shown in **Table 8.** The nitrogen contents of this set of barleys were within specification for the production of lager malt. Spire was similar in size and corn size distribution to Optic. Both the barleys were quite water sensitive.

Table 8 Barley Analyses

Variety	**Spire**	**Optic (control)**
Barley Ref.No.	01/14	01/12
Moisture (%) (after drying)	11.3	12.0
Total Nitrogen (%)	1.76	1.77
TCW (g)	42.5	40.7
Sieve Analysis (g)		
> 2.8	77.6	75.4
2.5-2.8	15.2	16.1
2.2-2.5	5.4	5.9
<2.2	1.8	2.6
Viability (%)	96	95
Germinative Energy (%)	97	98
Water Sensitivity (%)	15	29

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 Spire 86% and Optic 75%. Endosperm quality of the control was therefore somewhat poorer than the trial variety (i.e. Optic 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 9.**

Table 9. Malt Analyses small scale malting[1]

Parameter	No added Gibberellic Acid		With Gibberellic Acid	
Variety	**Spire**	**Optic**	**Spire**	**Optic**
Barley Ref. No.	01/14	01/12	01/14	01/12
Hot Water Extract (litre°/kg) coarse grind	306	310	307	313
Total Soluble Nitrogen (%)	0.70	0.67	0.74	0.71
Total Nitrogen (%)	1.64	1.70	1.63	1.64
Soluble Nitrogen Ratio	43	39	45	43
Free Amino Nitrogen (mg/litre)	172	148	188	164
Fermentability (%)	76	76	77	76
Viscosity (mPa.s)	1.50	1.47	1.48	1.47
DP (°IOB)	106	123	103	135
DU	56	61	59	63
Wort Clarity	Clear	Clear	Clear	Clear
Friability (%)	89	87	93	90
Homogeneity (%) [2]	96.8	96.9	98.2	98.1

[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*

<u>Carbohydrate Modification</u>
Spire malts showed significantly lower extract potential than the Optic control. This was the case even in the presence of GA, which did not appear to affect Spire HWE values.

<u>Protein Modification</u>
Spire exhibited higher levels of total soluble nitrogen (TSN) and free amino nitrogen (FAN) than the control, particularly when GA was not used. Consequently soluble nitrogen ratio (SNR) was also raised in the trial compared to the control.

<u>Cell-wall Modification</u>
Viscosity and Friability results indicate little difference between trial and control malts.

Amylolytic Enzyme Potential

The Spire malts show a slightly lower potential for DP (principally β-amylase) than the Optic control. The Spire DP was not increased when GA was used. DU values (α-amylase) were similar to the control in both cases.

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 five 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 10**.

Table 10. Pilot Malting, Process data

Variety	Spire	Optic
Barley Number	01/14	01/12
Malt Batch Number	890 P	889 P
Casting moisture(%)	47.9	47.9
Moisture at end of Germination (%)	46.2	43.4
Time to break point (hr)	24	21.5
Total kilning time (hr)	34	31.5

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 11.**

Table 11. Pilot malting, spring malt analyses

ANALYSIS	TARGET SPECIFICATION	Spire	Optic
Barley number	**-**	01/14	01/12
Malt Batch number	**-**	890 P	889 P
Moisture (%)	**4.0-5.0**	4.1	4.7
HWE2 (l°/kg dry)	**310-315**	306	310
HWE7 (l°/kg dry)	**305-310**	304	309
F/C Diff	**5 max**	2	1
Colour (EBC)	**2.0-3.0**	3.3	3.5
DP (°IOB)	**75 min**	70	86
TN (%dry)	**1.60-1.80**	1.67	1.66
SNR (%)	**38-42**	36	36
FAN (mg/l)	**140-180**	130	121
Fermentability (%)	**74-78**	75	74
Friability (%)	**85 min**	93	92
Homogeneity (%)	**96 min**	97.2	98.2
Beta- Glucan (mg/l)	**100 max**	68	77
Viscosity mPas	**1.45-1.65**	1.48	1.47

In spite of the generous pilot malting conditions provided for Spire the malt extract values obtained fell just short of the specification and were significantly lower than those obtained with the Optic control. This observation had also been noted in the preceding micro-malting results. Protein modification as assessed by SNR and FAN was slightly below specification in both malts but Spire, again, was just below specification for DP. Both the trial and control malts met the specification for fine/coarse difference, TN, fermentability, friability, homogeneity, β-glucan and viscosity.

Both the Spire and Optic malts were close enough to the overall lager malt specification to warrant pilot brewing.

4. Pilot Brewing

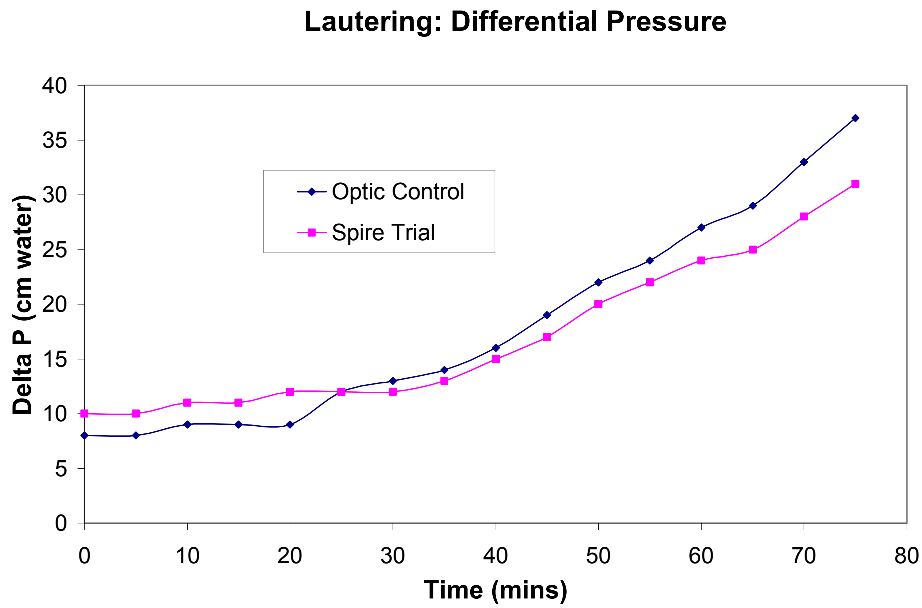
The pilot malts were used for brewing in the BRI pilot brewery, using standard process conditions for BRI 11°Plato lagers. Details of these are given in the **ANNEX 2 .** Process data for each brew is given in **Table 12.**

Table 12. Pilot brewing, process data

Parameter	Spire	Optic
Brew No.	17/02	16/02
Barley No.	01/14	01/12
Malt No.	890 P	889 P
Lauter time (min)	83	82
Gravity of last runnings (°gravity)	1006.9	1006.1
Wort clarity	Good	v. good
Trub settling time (min)	30	30
Final wort gravity pre-fermentation (°gravity)	1044.5	1044.0
Total volume wort (litres)	99	102
Yeast viability at harvest (%)	82	92
Final gravity (°gravity)	1006.2	1005.4
Gravity drop (° of gravity)	38.3	38.6

Both 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**.

Fig 7



There was no significant difference in run-off characteristics between the trial and the control. Both malts ran-off well with ΔP profiles typical of those expected in the pilot brewery lauter tun. The Spire mash required a longer period of wort recirculation at the start of lautering and while wort clarity was good, that of the Optic control was very good.

Pilot brewery extracts were broadly in line with the laboratory predictions and were ranked:

Optic>Spire

During fermentation the gravity drop was good for both the trial and the control beers **(see Fig 8 Fermentation Performance)** but yeast viability at the end of fermentation was rather low for Spire.

Wort analyses are shown in **Table 13.**

Colour, pH, OG, BU and nitrogen analyses are all within the normal ranges. Fermentability was good in all cases. There was no significant difference between the trial and control pitching worts.

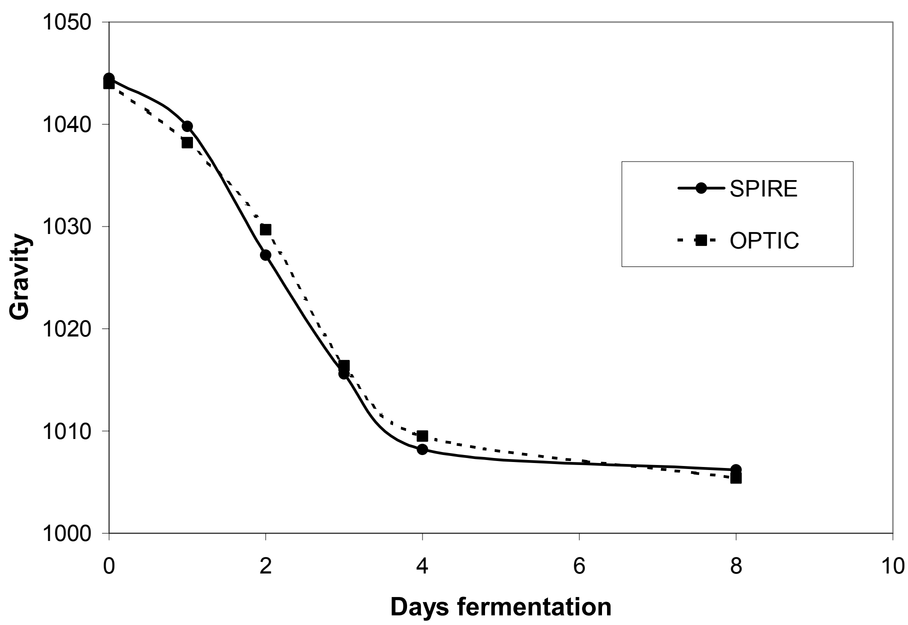
Table 13. Wort Analyses

Parameter	Spire	Optic
Brew No.	17/02	16/02
Barley No.	01/14	01/12
pH	5.47	5.61
Colour (°EBC)	14.1	14.8
Original Gravity °	43.6	43.5
Bitterness (BU)	33	31
Free Amino Nitrogen (mg/litre)	156	148
Total Soluble Nitrogen (mg/litre)	848	829
Fermentability (%)	73	73

Fermentation Performance

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

Figure 8. Fermentation profiles for beers



In each case the trial beer attenuated similarly to the control by the end of the standard fermentation period. Fermentation rates were very similar.

5. Beer Quality and Flavour

Results for standard beer quality analyses are shown in **Table 14.**

Table 14. Pilot brewing, beer analyses, standard parameters

Parameter	Spire	Optic
Brew No.	17/02	16/02
Barley No.	01/14	01/12
pH	4.03	4.05
Colour (°EBC)	10.1	10.9
Present Gravity (°)	5.00	4.20
Attenuation limit (°)	4.26	4.20
Head Retention Value (Nibem) (sec)	71,146, 214	82,162, 235
Bitterness (BU)	21	23
Free Amino Nitrogen (mg/litre)	48.2	37.8
Total Soluble Nitrogen (mg/litre)	552	524
Ethanol (% v/v)	5.02	5.06

All these parameters are within specification and present no anomalies. Beer PG values are close to 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 & 10**

Figure 9. Aroma and Taste scores for Spire beer

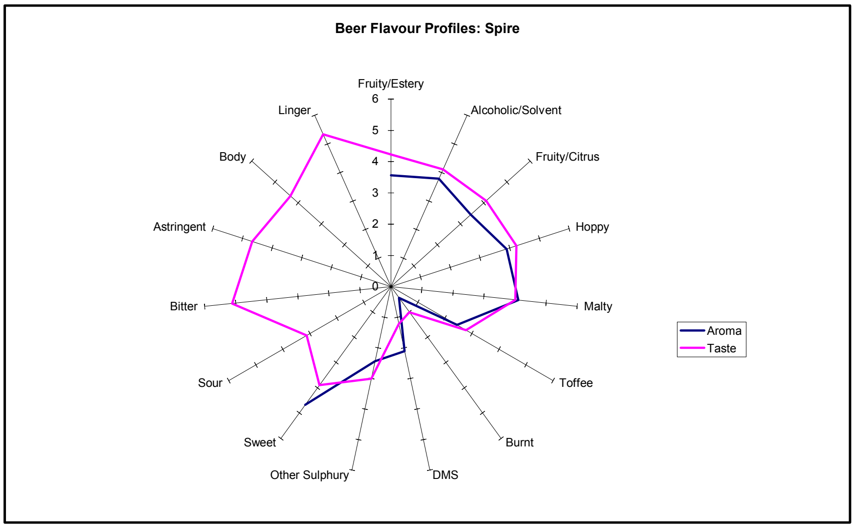
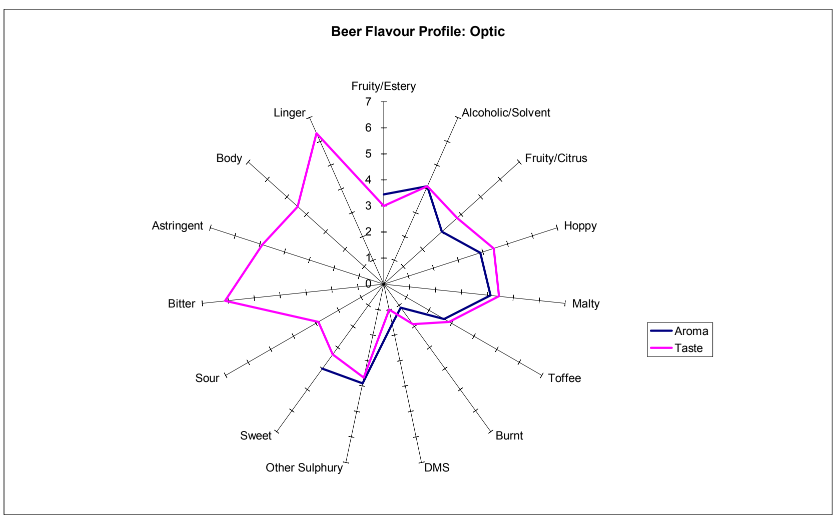


Figure 10. Aroma and Taste scores for Optic beer



Essentially all the beers were similar in character and there were no flavour taints attributable to barley variety. The trial beer had significantly more sweet, fruity character and was perceived as less bitter with a shorter linger (after- taste) compared to the control beer.

6. Conclusions

Spire

Barley TN was 1.76%, the same as the Optic control. Spire was similar in both size and germination characteristics to Optic. Viability was good but both barleys were quite water sensitive.
The Spire malts produced lower extracts and DP values than the control, although proteolysis was sometimes higher (see micro-malting results). The β-glucan levels in the Spire malts produced in the pilot maltings were higher than the control.
There were no significant differences in either lautering or fermentation performance when compared to the relevant controls. There were no special problems with wort turbidity; finished beer analyses and flavours were entirely normal.

Annex 1

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

STEEPING:

TIME (h)	**DIAMOND**	**PEARL**
1st steep	8	8
air-rest	14	14
2nd steep	10	10
air-rest	10	10
3rd steep	2	2
air-rest	2	2
TOTAL	46	46
STEEP TEMP (°C)	18	18
CAST MOISTURE (%)	46.5	45.7

GERMINATION:

GA	NONE USED			
5 DAYS	1 @ 15°C	1 @ 16°C	1 @ 17°C	2 @ 18°C

KILNING:

MEAN CONDITIONS	
Break time (h)	17
Post break air recirculation employed	
Total time (h)	27
Max curing temp (°C)	85

Annex 1

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

STEEPING:

TIME (h)	**SPIRE**	**OPTIC**
1st steep	8	8
air-rest	14	14
2nd steep	10	10
air-rest	10	10
3rd steep	0.3	0.2
air-rest	2	2
TOTAL	44.3	44.5
STEEP TEMP (°C)	18	18
CAST MOISTURE (%)	47.9	47.9

GERMINATION:

GA	NONE USED			
5 DAYS	1 @ 15°C	1 @ 16°C	1 @ 17°C	2 @ 18°C

KILNING:

MEAN CONDITIONS	
Break time (h)	23
Post break air recirculation employed	
Total time (h)	33
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$_2$N 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:
Diamond and Pearl

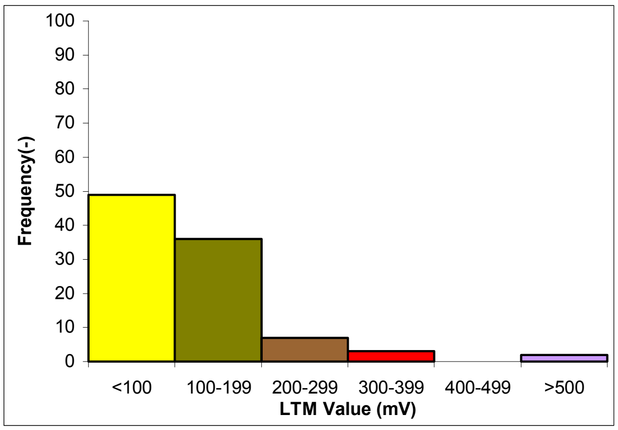
Spire and Optic
(see following Four pages)

BRI rapid LTM measurement

Sample Name:	**diamond**	Date:	**03/26/102**
Sample number:	**01 06**	Hour:	**2:40 PM**
Stage:	**Barley**		

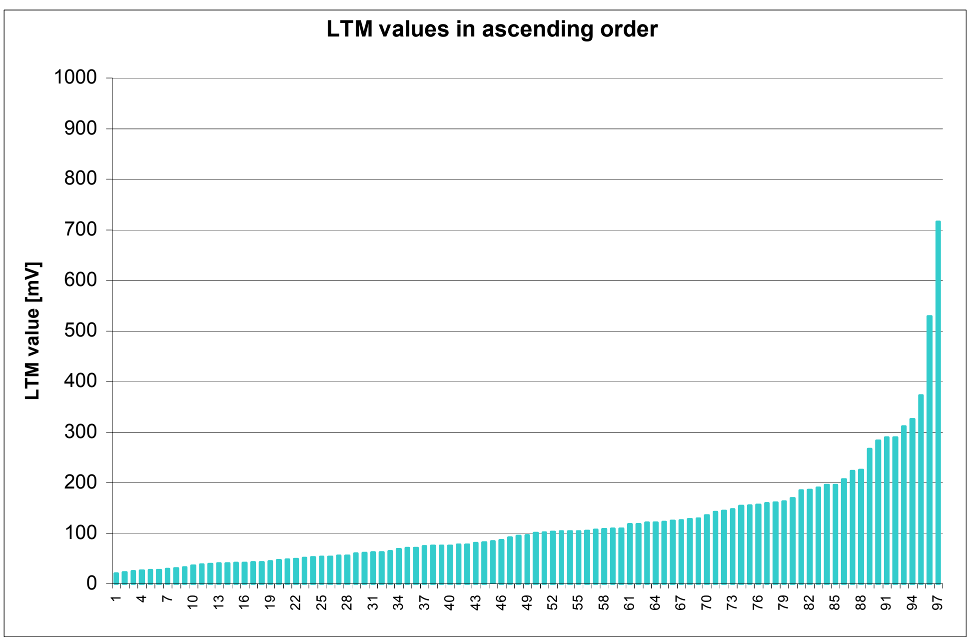
Filter 1: 1001 Filter 2: 95 Filter 3: 1

Distribution of grains with different endosperm structure



LTM Values	Count	Ratio
<100	49	51
100-199	36	37
200-299	7	7
300-399	3	3
400-499	0	0
>500	2	2
Total	97	100

Percentage of mealy grains: 88%

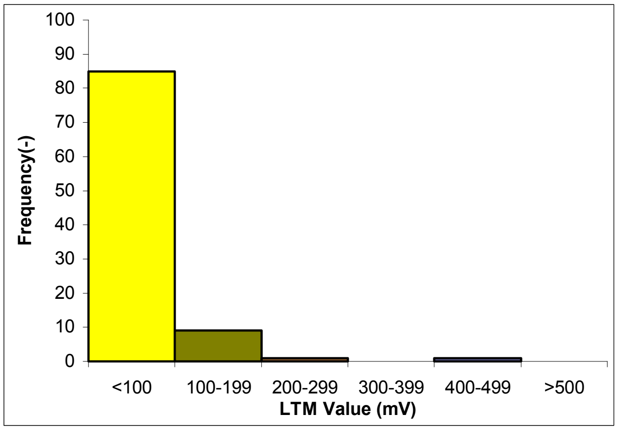


BRI rapid LTM measurement

Sample Name:	**pearl**	Date:	**03/26/102**
Sample number:	**01 05**	Hour:	**2:27 PM**
Stage:	**Barley**		

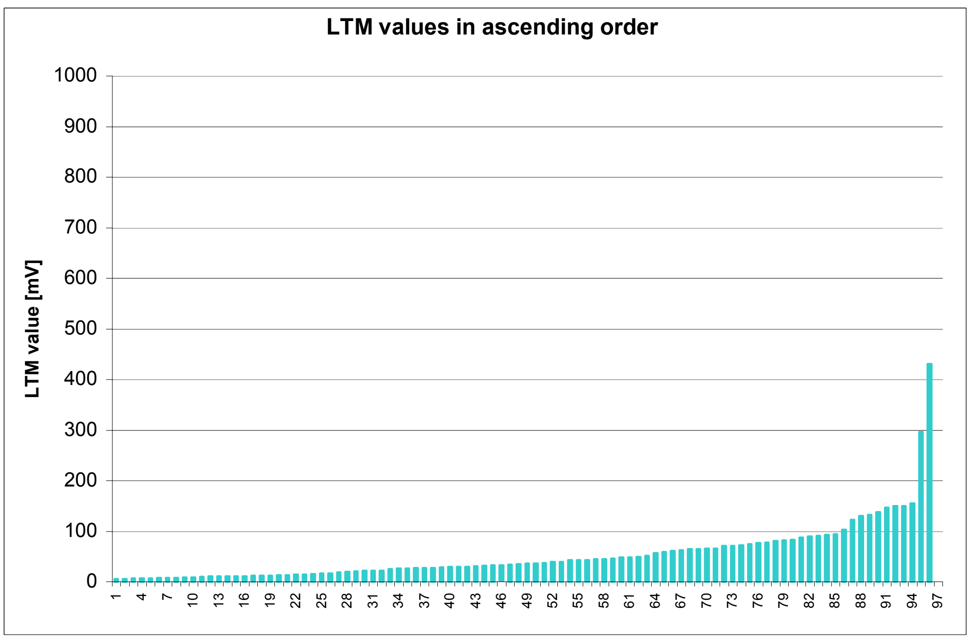
Filter 1: 994 Filter 2: 92 Filter 3: 2

Distribution of grains with different endosperm structure



LTM Values	Count	Ratio
<100	85	89
100-199	9	9
200-299	1	1
300-399	0	0
400-499	1	1
>500	0	0
Total	96	100

Percentage of mealy grains: 98%

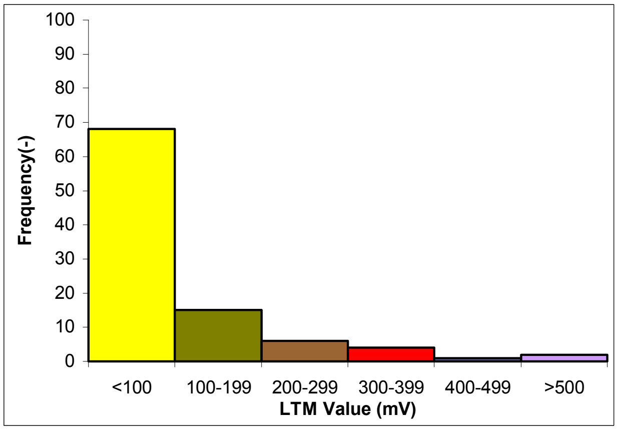


BRI rapid LTM measurement

Sample Name:	**spire**	Date:	**03/26/102**
Sample number:	**01 14**	Hour:	**2:55 PM**
Stage:	**Barley**		

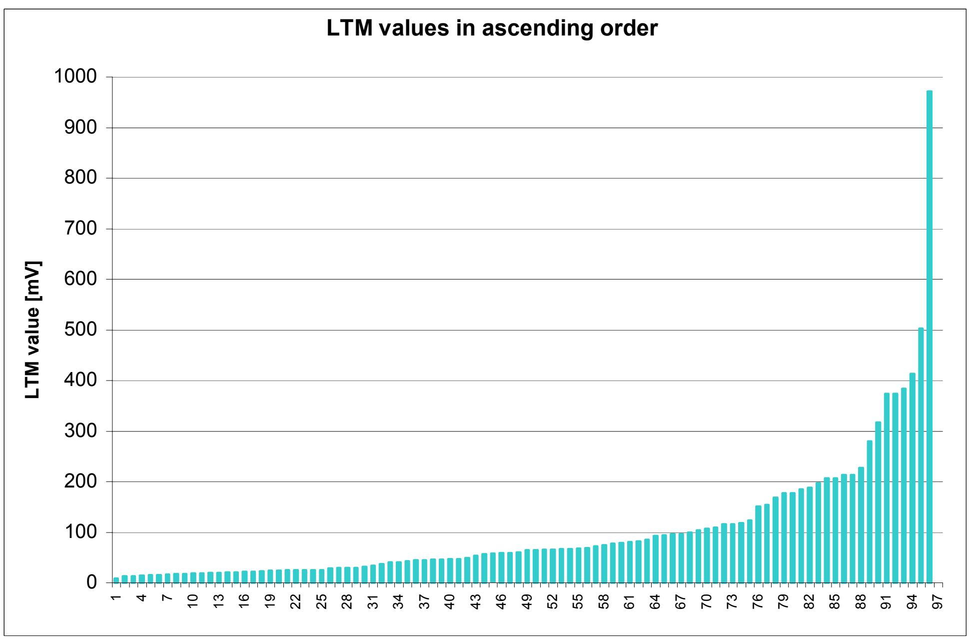
Filter 1: 1001 Filter 2: 95 Filter 3: 1

Distribution of grains with different endosperm structure



LTM Values	Count	Ratio
<100	68	71
100-199	15	16
200-299	6	6
300-399	4	4
400-499	1	1
>500	2	2
Total	96	100

Percentage of mealy grains: 86%

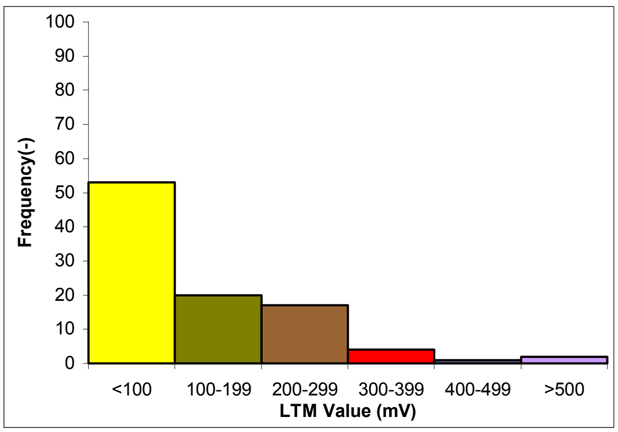


BRI rapid LTM measurement

Sample Name:	**optic**	Date:	**03/26/102**
Sample number:	**01 12**	Hour:	**4:05 PM**
Stage:	**Barley**		

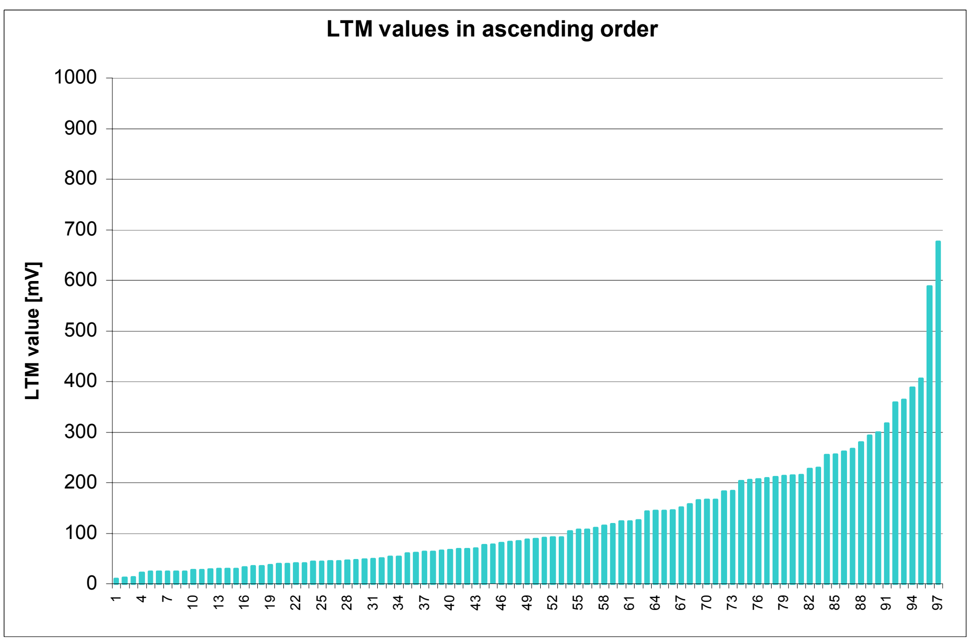
Filter 1: 1001 Filter 2: 96 Filter 3: 1

Distribution of grains with different endosperm structure



LTM Values	Count	Ratio
<100	53	55
100-199	20	21
200-299	17	18
300-399	4	4
400-499	1	1
>500	2	2
Total	97	100

Percentage of mealy grains: 75%



Annex 4

IOB Approved Varieties List for Harvest 2003

Crop type/Approval Status	Scotland and the North	Southern Regions
Winter/ Full Approval	**Regina** **Pearl**	**Fanfare** **Regina** **Pearl** **Leonie**
Winter/Provisional Approval		**Diamond (1)**
Spring/ Full Approval	**Optic** **Decanter** **Chalice**	**Chariot** **Optic** **Cellar**
Spring/Provisional Approval	**Cellar (2)**	**Tavern (2)**

(1) Provisional 1 Approval
(2) Provisional 2 Approval