



Effect of post-harvest storage period on barley germination and malt quality.

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Abstract

Malt with high extract, high enzyme levels and good modification is required to increase brewing yield and efficiency. To meet these requirements barley must overcome post-harvest dormancy and be able to germinate vigorously. The aim of this study was to determine the extent to which Australian barley changes during post-harvest storage.

Barley (*Hordeum vulgare* cv. Franklin) was stored at room temperature for one year and samples were taken monthly and stored at -18°C to slow further post-harvest changes. The germination energy (GE) and germination index (GI) of these samples were measured. Sub-samples were micro-malted and analysed. Prior to kilning, the activities of (1→3,1→4)-β-glucanase and α-amylase were determined.

During storage the 4mL GE was close to maximum and did not change. The 8mL GE increased slowly during the first 170 days and sustained a high value for the remaining period. The 4mL GI slowly increased over the 378 days of storage. Storage significantly increased the activities of (1→3,1→4)-β-glucanase and α-amylase at the end of germination. There was also a concomitant improvement in a number of key malting quality parameters.

Introduction

Malt with high enzyme levels (notably α-amylase and (1→3,1→4)-β-glucanase) and good modification is capable of producing high hot water extract values. These parameters are required to increase brewing yield and efficiency and are especially important in breweries where complex carbohydrate adjunct addition places greater demand on the hydrolytic enzymes supplied by the malt. To meet these requirements, barley must be able to germinate vigorously and produce sufficient amounts of hydrolytic enzymes during the limited time of the malting process. Barley dormancy is a major factor affecting the ability of the grain to germinate vigorously, and therefore may affect malt quality. Limited research on barley dormancy suggests that

changes during post-harvest storage and artificial dormancy breakage can affect malt quality (Gothard, 1984; Riis and Bang-Olsen, 1991).

Due to the usually favourable growing conditions in Australia as well as the varieties grown, dormancy in our barley crop is not strong but it is nevertheless a major factor constraining its maltability. The extent to which Australian barley changes during and after dormancy decay has not been extensively studied (Samuro *et al.*, 1980) and major deficiencies still exist in our understanding of the physiological basis of seed dormancy, vigour and germination (Bewley, 1997). It is important to understand the extent to which Australian barley germination parameters and malt quality change after harvesting to help improve malt quality and to assist in the selection of new barley varieties. The aim of this study was to determine to what extent Australian barley varieties improve after harvest (during and after dormancy decay) and how this may be reflected in enzyme levels and malt quality.

Methods

Australian barley (*Hordeum vulgare* cv. Franklin, grown in central Victoria in 1999) was stored at room temperature (22-27°C), between 38-44% relative humidity for one year. Each month a 3kg sample was sealed in a polyethylene bag and kept at -18°C to slow down further changes (Doran and Briggs, 1992; Woods and McCallum, 2000).

The 4mL and 8mL germination energy (GE) and 4mL germination index (GI) of each monthly sample was determined using the Analytica-EBC method (EBC, 1998) with a slight variation. The filter paper size was modified to fit within the recommended plastic dish to reduce test variation (Doran and Briggs, 1992). Grains were placed at random on the filter papers (not ventral side down).

Sub-samples of frozen barley (440g) were removed from the freezer and left at room temperature for 2 hours before commencing micromalting in an Automated Joe White Malting Systems Micromalting Unit, using a standard Joe White Maltings program. Malt quality was determined according to Analytica-EBC approved methods (EBC, 1998) and Scalar methods (Scalar, 1996) using a Scalar Automated Segmented Flow Analyser.

At the end of the germination process (prior to kilning) grains were removed and frozen (-18°C) for future enzyme analysis. Frozen germinated grains were homogenised using a CAT-X620 homogeniser in cold extraction buffer (α -amylase; 50mM sodium malate, 50mM sodium chloride, 2mM calcium chloride, 0.005% sodium azide, pH 5.2. β -glucanase; 40mM sodium acetate, 40mM sodium phosphate, 0.02% sodium azide, pH 4.6). The activity of α -amylase was determined using the Ceralpha method (McCleary and Sheehan, 1987). The activity of (1 \rightarrow 3,1 \rightarrow 4)-D- β -glucanase was determined using the Azo Barley Glucan method (McCleary and Shameer, 1987). Statistical analysis was performed using the Minitab statistical package.

Results and Discussion

Monthly germination parameters.

Monthly germination testing of samples indicated that dormancy was lost within the first 50 days of storage (i.e. 4mL GE values become greater than 95% after 3 days). The 4mL GE values remained high throughout the post-harvest storage period (Fig. 1).

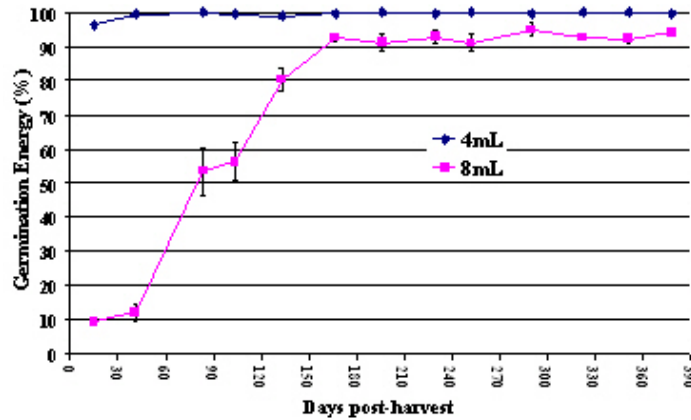


Figure 1. Variation of Germination Energy during post-harvest storage of barley for 378 days. Error bars represent standard error of the mean (n=4).

The 8mL GE values (which indicate the barley's water sensitivity) increased steadily from 10% to over 90% within the first 170 days of storage (Fig. 1). These results are consistent with other reports (Briggs, 1997). The 4mL GI results display an increase from 5 to 9 over the initial 250 days of post-harvest storage. After this time the 4mL GI values did not change significantly (Fig. 2).

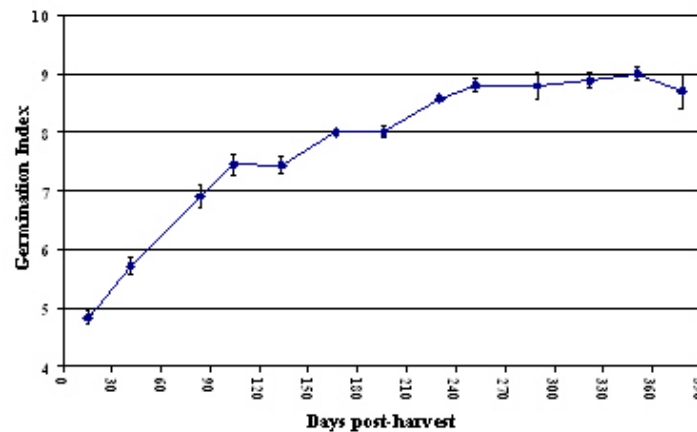


Figure 2. Variation of Germination Index during post-harvest storage of barley for 378 days. Error bars represent standard error of the mean (n=4).

Enzyme activity at the end of germination.

The activity of α -amylase and (1 \rightarrow 3,1 \rightarrow 4)- β -glucanase at the completion of germination significantly increased over the barley post-harvest storage period (Fig. 3). Shortly after harvest (15 days), relatively low levels of α -amylase and (1 \rightarrow 3,1 \rightarrow 4)- β -glucanase were produced. Significant increases in enzyme activity were observed up to 196 days of post-harvest storage. After this storage time, the activity of these enzymes continued to increase, but at a slower rate.

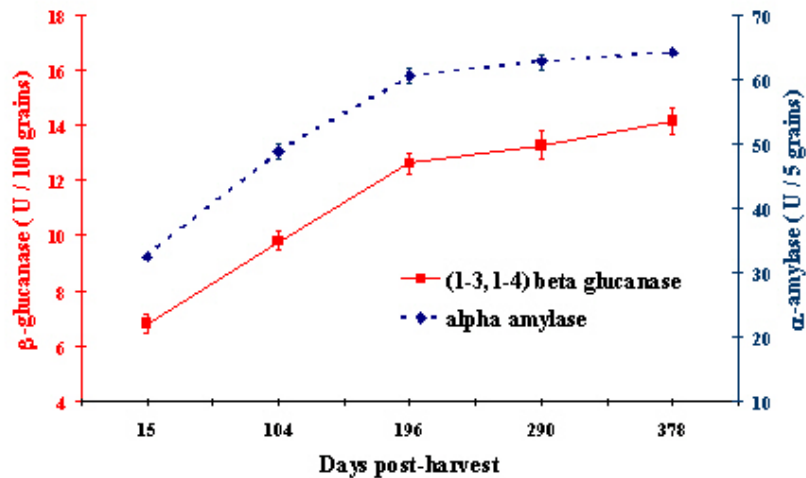


Figure 3. The effect of barley post-harvest storage period on enzyme activity (α -amylase and (1 \rightarrow 3,1 \rightarrow 4)- β -glucanase) at the end of germination. Error bars represent standard error of the mean (n=3).

Malt quality.

The quality of malt produced from stored barley increased throughout the study period of 378 days (Table 1). Malt analysis revealed that the diastatic power (DP) increased over the initial 104 days of barley storage and remained relatively stable thereafter. The malt hydrolytic enzymes, α -amylase and (1 \rightarrow 3,1 \rightarrow 4)- β -glucanase progressively increased over the 378 days of storage by 61% and 47%, respectively. There was a significant increase in malt extract of 2.1% over the first 290 days of barley storage, after which there were no further changes. The Kolbach index progressively increased throughout the 378 days by 41%, indicating that maturation resulted in increase protein degradation during malting, presumably as a result of increased proteolytic enzyme production (not measured).

From 15 days to 104 days of post-harvest storage there was a significant decrease in both wort- β -glucan and viscosity. After 104 days the wort viscosity was relatively stable. In comparison, the wort- β -glucan decreased to very low levels at 196 days. These observations are consistent with the progressive increases in (1 \rightarrow 3,1 \rightarrow 4)- β -glucanase activity during post-harvest storage. The Apparent Attenuation Limit (AAL) of the wort produced from the malt samples increased by 3.1% over the barley storage period. This increase is consistent with the increased enzyme levels throughout the post-harvest storage period. The colour of the wort significantly increased between 15 days and 104 days of storage, but changes thereafter were small.

Days Post-Harvest	Extract (% d.b.)	Wort Colour (EBC)	Total Protein (% d.b.)	Kolbach Index	DP (WK)	(α -amylase (DU)	(1 \rightarrow 3,1 \rightarrow 4) β -glucanase (U/kg)	Wort β -glucan (mg/L)	Wort Viscosity (cP)	AAL (%)
15	81.2 ^a	2.7 ^a	9.8 ^a	32.8 ^a	417 ^a	35.4 ^a	403 ^a	233 ^a	1.56 ^a	80.4 ^a
104	82.3 ^b	3.3 ^b	9.8 ^a	40.5 ^b	493 ^b	48.2 ^b	497 ^b	35 ^b	1.51 ^b	82.7 ^b
196	82.7 ^b	3.3 ^b	9.6 ^a	42.3 ^b	490 ^b	53.7 ^{bc}	545 ^c	21 ^b	1.51 ^b	83.0 ^b
290	83.3 ^c	3.4 ^{bc}	9.6 ^a	45.5 ^{cd}	505 ^b	56.2 ^c	580 ^d	16 ^b	1.52 ^b	83.4 ^b
378	83.1 ^c	3.6 ^c	9.6 ^a	46.2 ^d	489 ^b	57.0 ^c	594 ^d	17 ^b	1.52 ^b	83.3 ^b

Values with different letter superscripts are significantly different ($p < 0.05$).

Further research in this project has shown similar changes occur in other common Australian malting varieties during storage (Arapiles and Schooner) although the rates and extents of change vary. We are currently addressing the mechanisms responsible for enhanced germination and increasing malting quality of stored barley.

Conclusion.

The data presented in this paper indicate that Franklin barley grown in Victoria undergoes significant changes associated with dormancy decay during post-harvest storage at room temperature (22-27°C). These changes promote germination of the grain, resulting in increased enzyme production and improved malt quality. Initially, GE is a good indicator of dormancy decay but changes continue to occur after high GE values have been attained. These changes are associated with the increasing GI values.

Acknowledgements

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