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A preliminary screening of barleys for differences in β-glucan-related grain traits

A. Gianinetti, B. Ferrari, F. Finocchiaro, P. Frigeri and A.M. Stanca
CRA, Experimental Institute for Cereal Research, Fiorenzuola d'Arda (PC), Italy

SUMMARY – The presence of a peak of soluble β-glucan during malting has been suggested to indicate that β-glucan degradation occurs in two stages (Walker *et al*., 2001). In order to investigate this suggestion, we studied a set of 35 barleys with wide variability for grain and malting quality. As a preliminary approach, correlations between parameters were studied over the whole set, and trends of acid-extract viscosity were monitored during malting in 16 genotypes. No peak of acid-extract viscosity was observed in these barleys and no clues revealing a two-stage β-glucan degradation were obtained with this approach. Thus, a set of five genotypes having contrasting quality traits was chosen as representative of the variability existing in the whole collection and earmarked for more detailed studies.

Introduction

A two-stage model for β-glucan degradation has been assumed by Walker *et al*. (2001), based on previous literature and on their own experiments showing a peak of soluble β-glucans during malting. This peak was interpreted as revealing an inbalance between the solubilization and depolymerization stages of the β-glucan degradation process. To verify the presence of such an inbalance, and then to confirm the two-stage model in our materials, we performed a screening of barley genotypes. Initially, 35 two-rowed spring and winter barleys (either cultivars or experimental lines, hulled or hulless) grown at Fiorenzuola (Northern Italy) were harvested in 2002 and characterized for parameters related to β-glucans and malting quality. From the original set, 16 genotypes with contrasting traits were chosen as representative of the overall variability observed and analysed for changes in acid-extract viscosity during malting. The latter, in fact, correlates with changes in the level of soluble β-glucans (Zheng *et al*., 2000). Selection of contrasting genotypes was considered an important preliminary step for a more valuable characterisation of varietale effects on β-glucan degradation.

Barleys were malted and assayed for malting quality according to Gianinetti *et al*. (2005); soluble and insoluble β-glucans, as well as acid-extract viscosity, were assayed as detailed in Gianinetti *et al*. (in preparation). Water uptake was measured as the percentage of water absorbed by 10 g of grains incubated 5 h at 50 ℃ in 100 ml.

Results

Wide variability was observed for all the characters examined in the 35 genotypes (Table 1). Kernel size, expressed as thousand kernel weight (TKW) or kernel sieve fraction (KSF) >2.5 mm, varied consistently among the different barley types with the latter parameter being clearly influenced by the presence/absence of the hull (on average, hulless genotypes showed 15% less TKW and 62% less KSF >2.5 mm than hulled barleys; correspondently, the former also showed 20% less water uptake). Total β-glucan content was the lowest (3.1 %) in Fior 7148 and the highest (6.5 %) in CDC Candle. Broad differences were noted in the proportion of insoluble β-glucans, which ranged from 51% in Tea (feed barley) to 81% in Fior 6315. Zacinto showed the lowest acrospire index (ie the lowest germination speed) and the lowest friability. In contrast, Tremois had the highest acrospire index, the highest friability and the lowest wort viscosity. CDC Candle had the lowest HWE (61.9 %) and Extra the highest wort viscosity (1.91 cP).

Table 1. Mean values and ranges for quality traits for the whole initial set of 35 original genotypes

Genotype	TKW (g)	KSF >2.5mm (%)	KSF 2-2.5mm (%)	KSF >2.0mm (%)	Protein (%)	Total β-glucans (%)	Insoluble β-glucans (%)	Soluble β-glucans (%)	Insoluble β-glucan ratio (%)	Water uptake (%)	Acrospire index	Friability (%)	HWE (%)	Wort viscosity (cP)
MEAN	41	64	31	94	13.6	4.2	2.9	1.3	69	47	0.57	70	74.0	1.64
MIN	25	10	4	81	10.3	3.1	1.9	0.8	51	38	0.22	26	61.9	1.47
MAX	52	94	77	99	17.3	6.5	3.7	2.8	81	62	0.87	92	81.6	1.91

Correlations

Significant correlations between parameters are given in Table 2. Kernel size fractions correlated with each other, but the intermediate fraction (2.0 to 2.5 mm) was negatively linked to the overall size of the seed (both >2.0 and >2.5 mm). KSF values were not significantly related to TKW, possibly because of the hulless genotypes which had good TKW but low KSF (>2.5 mm). The only other parameter showing a significant relationship with the KSF (but not TKW) values was water uptake: it is known that thin kernels absorb water more rapidly than do larger ones (Bamforth and Barclay, 1993). Total β-glucan content was related to the amounts of both the soluble and insoluble fractions, and the proportion of insoluble β-glucans was negatively related to the proportion of soluble β-glucans. However, no significant relationship was noted between the two fractions, nor was the proportion of insoluble β-glucans related to the levels of total or insoluble β-glucans. This was interpreted as showing that genotypic differences in the proportion of insoluble β -glucans were small compared with the differences in the amount of total β-glucans, but significant in relation to the amounts of soluble β-glucans.

As expected, the contents of total and insoluble β-glucans were also positively correlated with wort viscosity but not with other parameters. Correspondingly, wort viscosity was negatively correlated with acrospire growth, friability, and HWE; however, although friability and HWE were correlated with each other, acrospire growth was significantly correlated with the former but not with the latter. The correlations are broadly consistent with those reported by Gianinetti *et al*. (2005).

Viscosity of acid extracts

Changes in acid-extract viscosity were monitored during malting in a subsample of 16 genotypes (Fig. 1) and are expected to reflect major differences in β-glucan degradation among genotypes (Zheng *et al*., 2000). Hence, the presence of a peak would support the occurrence of a two-stage process of β-glucan degradation. However, apart from differences in the starting values, the acid-extract viscosities showed an exponentially decreasing trend which was consistently similar among genotypes. Most starting values were crowded at about 2-3 cP with several others around 4 cP. Nevertheless, all the values converged to 1.2-1.3 cP after five days of malting. When the starting values of acid-extract viscosity were tested for correlations with the quality parameters, only total and soluble β-glucans showed significant correlations with it ($P<0.05$, not shown).

Table 2. Pearson's correlation coefficients. Significant correlations (P≤0.05) are evidenced in bold

	TKW (g)	KSF >2.5 mm (%)	KSF 2-2.5 mm (%)	KSF >2.0 mm (%)	Protein (%)	Total β-glucans (%)	Insoluble β-glucans (%)	Soluble β-glucans (%)	Insoluble β-glucan ratio	Water uptake (%)	Acrospire index	Friability (%)	HWE (%)	Wort viscosity (cP)
TKW (g)	1.00													
KSF >2.5mm (%)	*0.45*	1.00												
KSF 2-2.5mm (%)	*-0.45*	-0.98	1.00											
KSF >2.0mm (%)	*0.26*	0.72	-0.58	1.00										
Protein (%)	*0.14*	*-0.36*	*0.33*	*-0.35*	1.00									
Total β-glucans (%)	*-0.11*	*-0.16*	*0.19*	*0.03*	*-0.31*	1.00								
Insol. β–glucans (%)	*0.18*	*0.21*	*-0.17*	*0.31*	*-0.14*	0.72	1.00							
Soluble β-glucans (%)	*-0.29*	*-0.40*	*0.42*	*-0.19*	*-0.31*	0.83	*0.23*	1.00						
Insol. β-glucan ratio	*0.34*	*0.42*	*-0.41*	*0.29*	*0.23*	*-0.42*	*0.29*	-0.83	1.00					
Water uptake (%)	*-0.50*	-0.63	0.69	*-0.20*	*-0.00*	*0.16*	*-0.05*	*0.29*	*-0.20*	1.00				
Acrospire index	*-0.31*	*0.16*	*-0.20*	*-0.05*	*-0.32*	*-0.16*	*-0.23*	*-0.03*	*-0.05*	*-0.01*	1.00			
Friability (%)	*-0.23*	*0.23*	*-0.23*	*0.16*	*-0.04*	*-0.50*	*-0.40*	*-0.40*	*0.18*	*-0.10*	0.68	1.00		
HWE (%)	*-0.16*	*0.30*	*-0.25*	*0.44*	*-0.19*	*-0.53*	*-0.31*	*-0.50*	*0.31*	*-0.00*	*0.36*	0.67	1.00	
Wort viscosity (cP)	*0.37*	*-0.08*	*0.09*	*-0.02*	*-0.04*	0.64	0.59	*0.43*	*-0.12*	*0.00*	-0.58	-0.83	-0.70	1.00

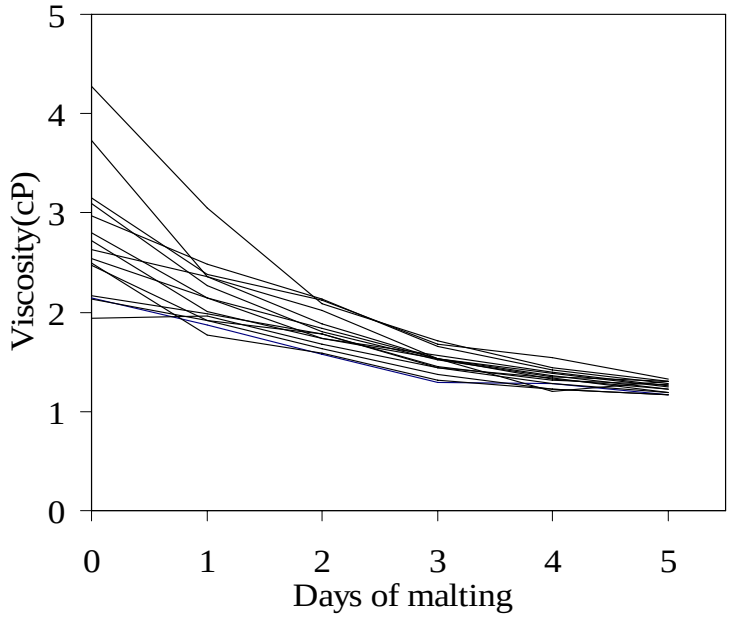

Fig. 1. Viscosity of acid-extracts during malting.

Discussion

No peaks of acid-extract viscosity corresponding to soluble β-glucans were observed in our materials, providing no evidence for a two-stage process of β-glucan degradation. More accurate studies using a direct β-glucan assay are, therefore, needed to verify whether a two-stage degradation model exists. To this aim, five genotypes differing widely in grain traits and malting quality (Table 3), were chosen as representative of the variability existing in the original set of 35 barleys (compare with ranges in Table 1). Identification of this set of genotypes is a first step for further studies of β-glucan degradation, and represents the main result of this preliminary study.

Table 3. Origin, grain traits and malting quality of the five barley genotypes selected for more detailed studies

Genotype	Origin	Type	TKW (g)	KSF >2.5 mm (%)	KSF 2-2.5 mm (%)	KSF >2.0 mm (%)	Water uptake (%)	Acrospire index	Friability (%)	HWE (%)	Wort viscosity (cP)
CDC Candle	Canada	hulless	30	10	77	87	61	0.60	47	61.9	1.87
Extra	Austria	feeding	49	91	8	99	49	0.40	45	71.0	1.91
Scarlett	Germany	malting	38	89	10	99	52	0.86	91	81.6	1.55
Fior 6315	Italy	feeding	47	73	20	93	47	0.42	68	66.3	1.79
Fior 7054	Italy	malting	40	55	34	90	50	0.73	79	75.4	1.47

As malting quality is linked to β-glucan degradation (Bamforth and Barclay, 1993), the use of contrasting barleys with very differing malting quality will allow a wide range of structural variation to be studied, giving more definitive results.

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