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Studies on the beta-glucan content of hull-less barley

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Abstract

The interest in barley food is currently increasing since numerous studies have verified health benefits of barley foods due to beta-glucan, the major soluble fibre component. We investigated the beta-glucan content of 105 hull-less barley genotypes in 14 environments. A significant variation in beta-glucan content was found both for genotypes, as well as for environments and their interaction. However, the genotypic effect was much greater than any other effect. Highest beta-glucan contents were found in 'waxy' varieties and some genetic resources. Data from the multi-environment experiment were also used to establish a NIRS calibration which allows an easy, rapid, reliable and cheap determination of beta-glucan in hull-less barley breeding material in the future.

Keywords

Cholesterol, dietary fibre, functional food, healthy food, *Hordeum vulgare*, NIRS

Introduction

Mixed-linkage beta-glucans (BG) are unique to the cell walls of grasses (Poaceae). Especially large amounts are localized in oats (*Avena sativa*) and barley (*Hordeum vulgare*). Although a minor component of the whole grain, BG can significantly affect industrial utilization of barley. High levels reduce malt extract yields and cause filtration problems at various stages in the brewing process as well as beer hazes. In animal nutrition BG reduces the availability of energy and protein in poultry fed diets (MACGREGOR and FINCHER 1993). On the other hand BG is considered to be nutritionally beneficial in human diets. Barley BG can help to reduce cholesterol (NEWMAN et al. 1989, MCINTOSH et al. 1991, BEHALL et al. 2004, KEENAN et al. 2007, SHIMIZU et al. 2008), control body weight and prevent obesity (SLAVIN 2005, SHIMIZU et al. 2008), reduce glucose and insulin response (BEHALL et al. 2006a, NILSSON et al. 2006), reduce blood pressure (BEHALL et al. 2006b), lower the risk for type 2 diabetes (HINATA et al. 2007, KOCHAR et al. 2007) and promote a prebiotic effect (SNART et al. 2006). In accordance with the EU Regulation No 1924/2006 on nutrition and health claims made on foods a number of entities filed an approval procedure toward registering BG-containing products as health beneficial products (for further information see http://registerofquestions.efsa.europa.eu/roqFrontend/questionsListLoader?panel=NDA&foodsectorarea=26).

In the present study hull-less barley varieties and genetic resources were investigated for their total BG content over various environments and cultivation systems. The aim of the work was to (1) search for barley genetic resources with high genotypic BG levels and to (2) establish a NIRS calibration for BG content.

Material and methods

Both organic and conventional field trials with a total of 105 hull-less barley genotypes were carried out since 2003 at various sites in eastern Austria. Grain samples were available from 14 environments, i.e. year × site combinations. Grain samples were sifted with a Sortimat laboratory machine (Pfeuffer GmbH, Kitzingen, Germany). Generally, only plump kernels >2.5 mm were used for analysis. Grains were milled into whole-grain flour using a model ZM100 ultracentrifugal mill (Retsch GmbH & Co KG, Haan, Germany) equipped with a 250 µm sieve.

Total BG content was determined enzymatically using Megazyme kits (Megazyme Int. Ireland Ltd., Bray, Wicklow, Ireland) following the standard method (ICC Standard Method No. 166, AACC Method 32-23, AOAC Method 995.16). In brief, milled barley samples were suspended and hydrated in a sodium phosphate buffer solution of pH 6.5 and incubated with purified lichenase enzyme (specific, endo-(1→3),(1→4)-β-D-glucan 4-glucanohydrolase, EC 3.2.1.73). An aliquot of the filtrate was then reacted to completion with purified β-glucosidase enzyme (EC 3.2.1.21). The glucose produced was assayed using a glucose/peroxidase (GOPOD) reagent. The BG contents were determined in 3 to 4 replicated measurements and are reported as % on dry basis.

Moreover, whole-grain flour of the samples was subjected to NIR spectra measurement by four different NIRS instruments (Tecator 1241 for transmission measurements, NIR-Systems 6500 for reflectance and transmission measurements (all Foss Analytical AB, Höganäs, Sweden), Matrix I for reflectance measurements (Bruker Optics, Ettlingen, Germany)) with different measuring principles (NIT, dispersive NIR, and FT-NIR) (SCHMIDT et al. 2009). Data from the chemical analyses were statistically analysed by the MIXED procedure of SAS 9.2 software (SAS Institute,

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Inc., Cary, NC) with genotype as fixed effect, and environment and genotype by environment interaction as random effects. Mean comparisons were carried out as one-sided (lower performance) Dunnett's t-test using the variety with the highest average performance, i.e. Wanubet, as control.

Results and discussion

A large variability in BG content (3.4-7.3%) was observed for the investigated plant material. Highest levels of BG were found in some 'waxy' varieties from the USA and Canada. Similar levels were identified in some genetic resources, e.g. Purple Nudum and Lih Dhanra Gal from the Himalaya regions, Debre Zeit AES2 from Ethiopia and Krehls Nacktgerste from Germany (*Table 1*). Mixed model analysis of variance revealed significant genotypic, environmental and interaction effect. The variance component for genotypes (0.35) was approximately double than that for the interaction term (0.18) and higher than that for environments (0.29). Effects of the environment and genotype by environment interactions have been well established in numerous other studies, although all studies revealed that the genetic background is more important (MORGAN and RIGGS 1981, ÅMAN and GRAHAM 1987, PÉREZ-VENDRELL et al. 1996).

Dispersive NIRS instruments showed suitability for supervision of breeding experiments and BG monitoring in food industries (R^2>0.78). Industrially used NIT instruments are suitable for only a rough selection. FT-NIRS was able to perform analytical analyses (R^2=0.96–0.98). For detailed results and discussion see SCHMIDT et al. (2009).

Conclusions

Levels of BG in several hull-less barley varieties and/or genetic resources are sufficiently high to provide high enough amounts of BG in end products to fulfil the EU requirements for labelling as 'source of fibre' or 'high fibre'. Rapid, reliable and cheap determination of BG by NIRS is possible and should allow an easy screening of a multitude of germplasm in hull-less barley breeding programmes.

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Table 1: **Best linear unbiased estimators (BLUE) for β-glucan (BG) content (% db) of hull-less barley. Varieties printed in bold are not significantly different from the highest performing variety Wanubet.**

Variety	BG	Variety	BG	Variety	BG
Wanubet	**7.29**	AE 13	4.89	IPZ 27215-4018	4.39
CDC Candle	**6.44**	GE 003	4.88	IPZ 25649-4045	4.38
Washonubet	**6.44**	NG 3.10-7	4.87	57002604	4.35
Purple Nudum	**6.23**	57002603	4.87	IPZ 25902-4026	4.30
Lih Dhanra Gal	**5.98**	Ethiopia 179	4.86	57003605	4.29
Debre Zeit AES2	**5.87**	Indian 3	4.81	IPZ 27837-4016	4.28
Krehls Nacktgerste	**5.86**	Black Hulless	4.81	57002608	4.26
HB 803	5.58	IPZ 25902-4011	4.80	57002605	4.23
Krim Nacktgerste	5.54	Ethiopia 96	4.76	IPZ 27200-4002	4.22
Armenische Nacktgerste	5.53	57004601	4.68	KM 1910B	4.22
Merlin	5.46	CI 666	4.68	IPZ 27836-4014	4.20
Kraftborn	5.43	IPZ 25904-4037	4.68	57002609	4.17
White Hulless	5.36	57003607	4.67	GE 040 Sel Blaukörnig	4.15
BOKU SNG-04	5.32	IPZ 27501-4011	4.67	KM 2384	4.10
57002601	5.25	Taiga	4.66	57003602	4.07
Murasaki Hadaka	5.23	Gho 1	4.65	IPZ 27424-4006	3.99
IPZ 25902-4012	5.17	Ethiopia 147	4.65	IPZ 25861-4054	3.99
IPZ 27196-4019	5.17	Lawina	4.61	Torrens	3.95
Himalayense 5	5.17	IPZ 27208-4003	4.61	Hora	3.86
57003601	5.17	57003604	4.59	95003-8	3.84
57002602	5.16	00/900/5N	4.56	KM 2074	3.81
Priora	5.14	Sama 9	4.55	Namoi	3.77
57003603	5.12	IPZ 27501-4012	4.55	Italienische Nacktgerste	3.75
BVAL 358163	5.09	57001603	4.53	Nackta	3.72
57002606	5.09	IPZ 27500-4008	4.52	00/900/19/3/7	3.71
Violaceum 2	5.08	KM 1910A	4.50	Digersano	3.64
Hiberna	5.07	57001601	4.47	Deutsche Nacktgerste Großkörnig	3.64
Ethiopia 12	5.04	Rondo	4.44	00/900/19/6/8	3.60
GE 090	5.04	IPZ 25904-4038	4.44	00/900/19/6/11	3.50
BBA 1035	5.00	KM 2283B	4.43	00/900/19/3/13	3.49
57003606	4.99	Addis Ababa 56	4.43	00/900/19/3/1	3.38
KM 2283A	4.94	Black Naked	4.42	00/900/14/3/10	3.37
Taastrup 625	4.94	IPZ 27200-4001	4.42	57002607	3.37
IPZ 25654-4007	4.92	57001602	4.41	00/900/19/6/4	3.37
GE 037	4.91	IPZ 27503-4013	4.40	00/900/19/3/12	3.34

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