LACC IGW

13th International Gluten Workshop

CIMMYT
International Maize and Wheat Improvement Center

14-17 March 2018

Hilton Reforma Hotel
Mexico City, Mexico

Proceedings

UCOPress
Editorial Universidad de Córdoba

LACC IGW

13th International Gluten Workshop

14-17 March 2018

Hilton Reforma Hotel
Mexico City, Mexico

Proceedings

CIMMYT
International Maize and Wheat Improvement Center

Carlos Guzman
(Editor)

UCOPress
Editorial Universidad de Córdoba

LACC/IGW. 13th International Gluten Workshop. Proceedings.
142 p.; 21x27cm.; il. color.
Editado por Carlos Guzmán
Editado por UCOPress. Editorial Universidad de Córdoba

LACC/IGW. 13th International Gluten Workshop. Proceedings.

Campus de Rabanales. Ctra. Nac. IV, km. 396, 14071 – Córdoba
http://www.uco.es/ucopress/ — ucopress@uco.es
Teléfono: 957212165

Adaptación a ebook: Lucía Trinidad Figueredo Fernández

ISBN: 978-84-9927-493-5

Exploiting natural and induced variation to improve the content and composition of dietary fibre in wheat grain

Alison Lovegrove[1], Amy Plummer[1], Abigail Wood[1], Diana Passmore[1], Andrej Kosik[1], Sam Reynolds[1], Jackie Freeman[1], Till Pellny[1], Rowan Mitchell[1], Mehmet Ulker[2], Mariann Rakszegi[3], Zoltan Bedo[3], Marie-Reine Perretant[4], Gilles Charmet[4], Luzie Wingen[5], Michelle Leverington[5], Suchismita Mondal6, Ravi Singh[6], Carlos Guzman[6], Simon Griffiths[5], Peter shewry[1]

[1] Rothamsted Research, West Common, Herts AL5 2JQ (alison.lovegrove@rothamsted.ac.uk)
[2] Bardakçı Mahallesi, Yüzüncü Yıl Üniversitesi Kampüsü, 65090 Tuşba/Van, Turkey
[3] Centre for Agricultural Research, MTA Agrártudományi, Kutatóközpont, Martonvásár, Hungary
[4] INRA, 5 chemin de Beaulieu, 63000 Clermont-Ferrand, France
[5] John Innes Centre, Norwich Research Park, Colney Lane, Norwich NR4 UH
[6] CIMMYT Km. 45, Carretera, México-Veracruz, Texcoco CP 56237 Edo. de México, Mexico

ABSTRACT
The major dietary fibre (DF) components of wheat grain are arabinoxylan (AX) and β-glucan. Both components vary in their amount, composition and properties in different grain fractions, with white flour being lower in total fibre than bran but having a higher proportion of soluble fibre. Cereal fibre has established health benefits, reducing the risk of a number of chronic diseases, including type II diabetes. A wide range of wheat germplasm has been screened for natural variation in the amount of AX and we have analysed four mapping populations to develop molecular markers for high AX to aid exploitation by breeders.

INTRODUCTION
Wheat is the major staple food in most temperate countries, including Europe and North America, and consumption is increasing globally. It makes a significant contribution to the human diet, providing energy and protein and also a number of essential or beneficial components, including B vitamins, minerals and dietary fibre. Cereal fibre has established benefits in reducing the risk of several chronic diseases, including type II diabetes, cardiovascular disease and some types of cancer. However, the consumption of fibre is below the recommended daily intake in most countries. Improving the content and composition of wheat fibre is therefore an attractive strategy to improve the health of large populations at low cost.

The major dietary fibre (DF) components of wheat grain are the cell wall polysaccharides, particularly arabinoxylan (AX) which is composed of the pentose sugars arabinose and xylose, and mixed linked β-glucan which is a polymer of the hexose sugar glucose (Mares and Stone 1973). The EU FP6 HEALTHGRAIN project reported substantial variation in the amount and composition of these components in bran and white flour of 150 diverse wheat genotypes (Gebruers et al. 2008) with comparisons of 26 genotypes grown in 6 environments demonstrating that a high proportion of this variation was heritable (Shewry et al. 2010). This study also showed that the Chinese cultivar Yumai 34 had the highest contents of both total and soluble AX. However, this study only sampled a small proportion of the total genetic diversity in bread wheat and we have therefore determined the dietary fibre content in white and wholemeal flour in a wider range of germplasm. We have also determined the content of AX in in white flour of several mapping populations in order to identify QTLs and molecular markers to enable breeders to produce new elite wheat lines with increased AX content.

MATERIALS AND METHODS
Plant material. The Watkins collection of landraces representing global diversity in the 1920s and 1930s collected from 32 European, Asian and North African Countries (Wingen et al. 2014). CIMMYT wheat lines were grown on in Ciudad Obregón, Sonora, northwestern México, during 2015-2016. The trial was planted under optimum irrigation through the drip method in flat seedbeds (> 500 mm); and planted in

flat seedbeds with full basin irrigation. The Yumai-34 x Ukrainka population was developed at ARHAS, Martonvasar, (Tremmel-Bede et al. 2017). Wholemeal flour was produced using a ball mill (Glen Creston, Stanmore, U.K.) and white flour as previously described using a Chopin CD1 mill (Anders et al. 2012), with the 150 µm fraction used for analyses.

Pentosan assay. Total pentosan content of wholemeal flour was determined as described by Douglas (1982) and Finnie et al. (2006).

Monosaccharide analysis. TFA hydrolysis of white flour was as described by Tryfona et al. (2010) and the monosaccharides analysed by HPLC.

RESULTS AND DICUSSION

Identification of sources of variation in AX

A preliminary survey of the core collection of Watkins landraces (~100 lines) grown at the John Innes Centre in 2013 showed wide variation in the contents of total and water-extractable AX (determined as pentosans) in wholemeal flour (Fig. 1).

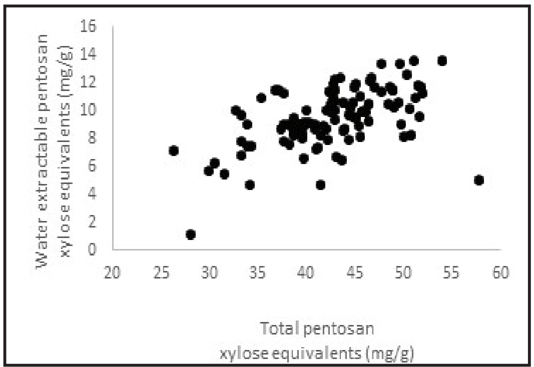

Figure 1. Contents of water-extractable and total pentosans from wholemeal flours of the Watkins core collection grown in the Norfolk (UK) in 2013.

A set of 24 genotypes of bread wheat were grown by CIMMYT under two different field managements in Mexico in 2015-2016. These lines were selected to include both old and recent cultivars, in order to maximise diversity. Determination of water-extractable AX in white flour showed substantial variation in amount, with the amount present in the line PBW343 being three times that in Huw 234. However, there were no clear differences in AX content between older and more recently bred cultivars. These data also show that the high AX trait is very stable across the two different environments (Fig. 2), confirming the high heritability previously determined in the Healthgrain study (Shewry et al. 2010).

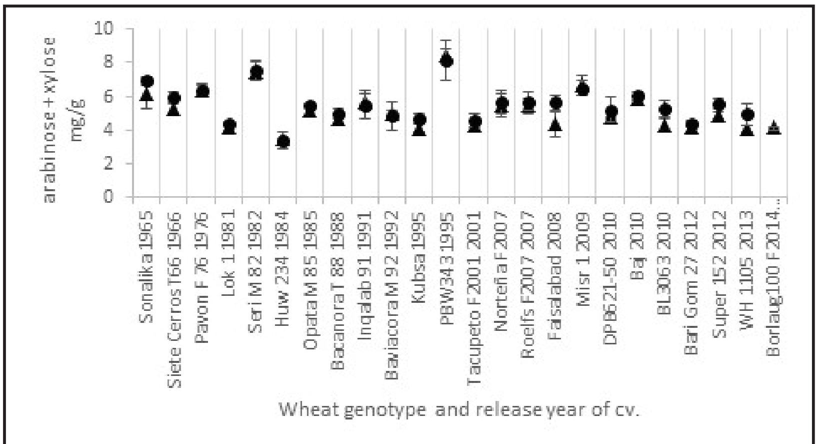

Figure 2. Water-extractable AX (determined as the sum of arabinose and xylose) in white flour of 24 CIMMYT bread wheat lines grown on two sites in Mexico (● Flat seed beds with drip irrigation and ▲ Flat seed beds with full basin irrigation) in 2015-2016.

Genetic analysis of AX amount and properties

Several mapping populations were developed to identify QTLs for high AX, including a population of recombinant inbred lines from the cross Yumai-34 x Ukrainka (Tremmel-Bede 2017). Analysis of F6 lines of this population grown at Rothamsted in 2012-2013 showed a linear relationship between total AX and water-extractable AX in white flour (Figure 3). Analysis of this and several other mapping populations has identified a major QTL for AX in Yumai 34 and the development of molecular markers that can be used by breeders to facilitate the commercial breeding of wheat lines with high contents of total and soluble AX fibre in white flour.

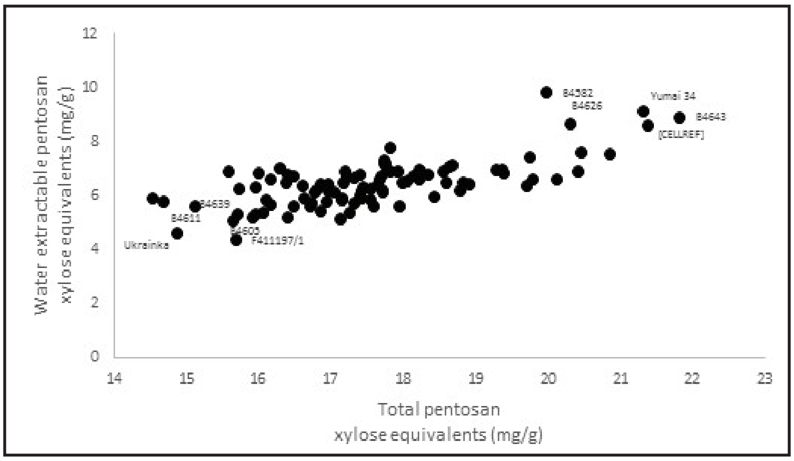

Figure 3. Contents of total and water extractable (soluble) AX (determined as pentosans) in white flour from F6 recombinant inbred lines from the cross Yumai-34 x Ukrainka.

REFERENCES

Anders N, Wilkinson MD, Lovegrove A, Freeman J, Tryfona T, Pellny TK, et al. (2012) Glycosyl transferases in family 61 mediate arabinofuranosyl transfer onto xylan in grasses. Proceedings of the National Academy of Sciences USA 109: 989-993.

Douglas SG (1981) A Rapid Method for the Determination of Pentosans on Wheat Flour. Food Chemistry 7: 139-145

Finnie SM, Bettge AD, Morris CF (2006) Influence of Cultivar and Environment on Water-Soluble and Water-Insoluble Arabinoxylans in Soft Wheat. Cereal Chemistry 83: 617-623.

Gebruers K, Dornez E, Boros D, Fras A, Dynkowska W, Bedo Z, Rakszegi M, Delcour JA, Courtin CM (2008) Variation in the content of dietary fiber and components thereof in wheats in the HEALTHGRAIN diversity screen. Journal of Agricultural and Food Chemistry 56: 9740–9749.

Mares DJ, Stone BA (1973) Studies on wheat endosperm. I. Chemical composition and ultrastructure of the cell walls. Australian Journal of Biological Sciences 26:7 93-812.

Shewry PR, Piironen V, Lampi AM, Edelmann M, Kariluoto S, Nurmi T, et al. (2010) The HEALTHGRAIN wheat diversity screen: effects of genotype and environment on phytochemicals and dietary fiber components. Journal of Agricultural and Food Chemistry 58: 9291-9298.

Tremmel-Bede K, Lang L, Torok K, Tomoskozi S, Vida G, Shewry PR, Bedo Z, Rakszegi M (2017) Development and characterization of wheat lines with increased levels of arabinoxylan. Euphytica 213: 291-314.

Tryfona T, Liang HC, Kotake T, Kaneko S, Marsh J, Ichinose H, et al. (2010) Carbohydrate structural analysis of wheat flour arabinogalactan protein. Carbohydrate Research 345: 2648-2656.

Wingen LU, Orford S, Goram R, Leverington-Waite M, Bilham L, Patsiou TS, et al. (2014) Establishing the A. E. Watkins landrace cultivar collection as a resource for systematic gene discovery in bread wheat. Theoretical and Applied Genetics 127: 1831-1842.

Rothamsted Research receives grant-aided support from the Biotechnology and Biological Sciences Research Council (BBSRC) of the U.K. and the work forms part of the Designing Future Wheat Strategic Program (BB/P016855/1).