

Wheat Sensitivities: Sorting Fact from Fiction

Lisa Kissing Kucek, PhD
Research Geneticist
USDA-ARS-DFRC

Available open access online:

“The Grounded Guide to Gluten”

Lisa Kissing Kucek¹, Lynn Veenstra²,
Plaimein Amanuaycheewa³, and Mark E. Sorrells²

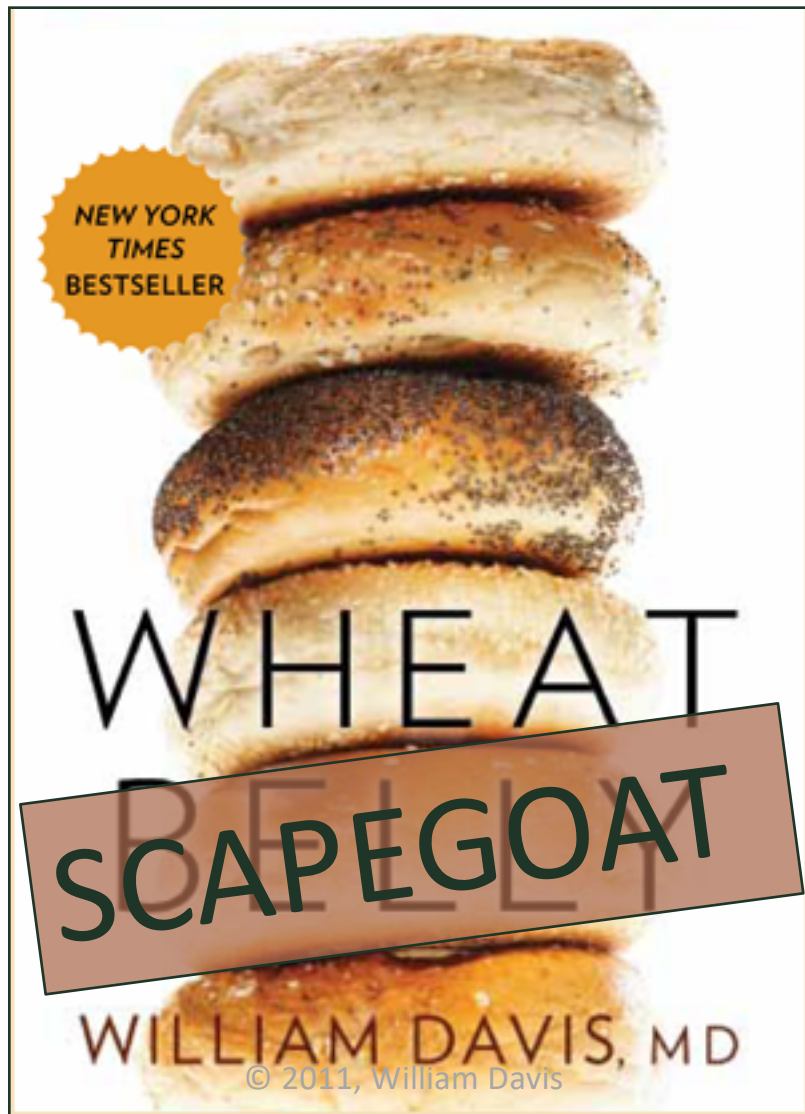
Comprehensive Reviews in Food Science and Food Safety

2015



Poll:

How many people in your close circle of friends and family avoid wheat in their diet?



“Wheat gluten isn’t bad”



-National Association of Wheat Growers



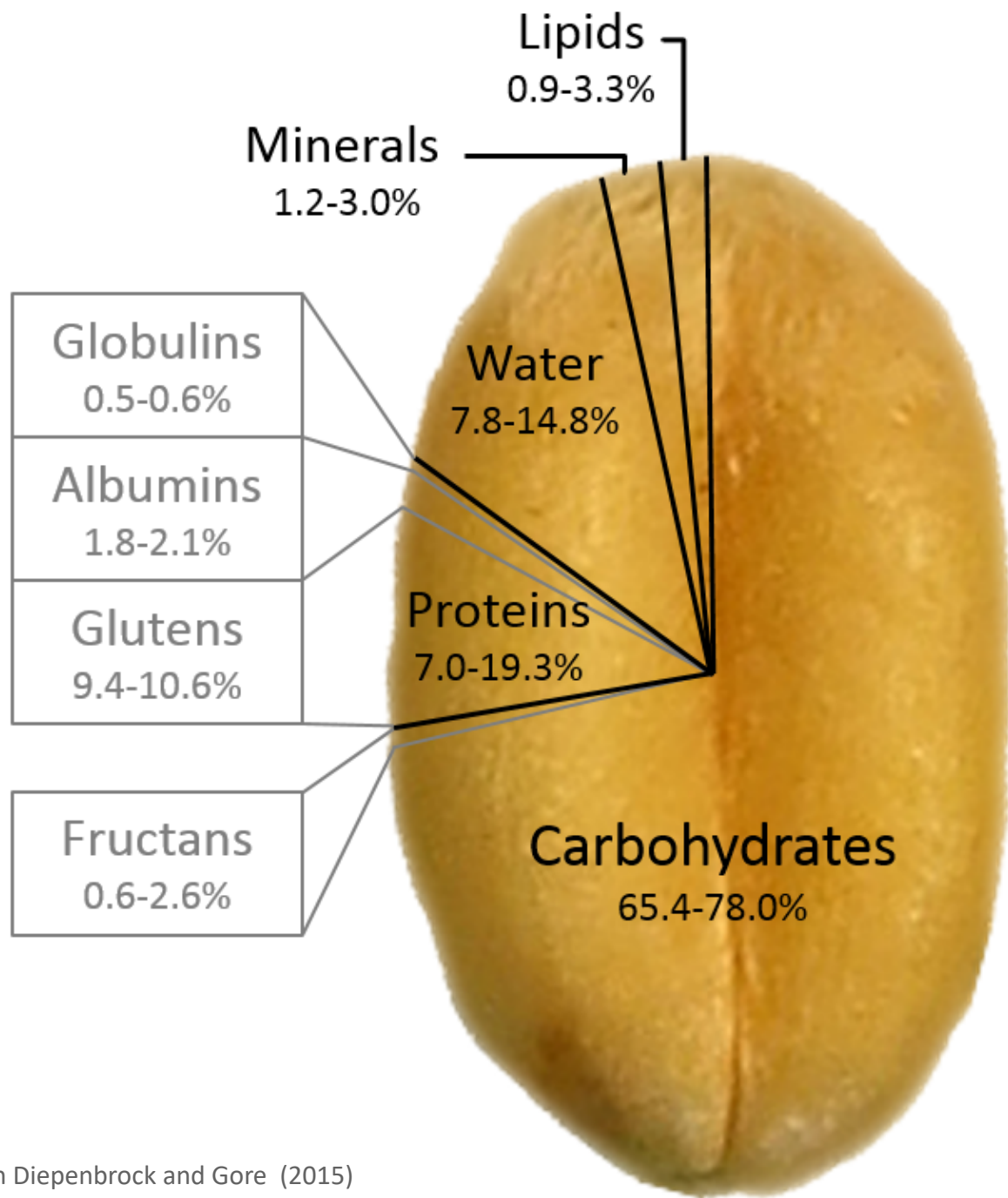


Figure from Kissing Kucek et al. (2015), based on Diepenbrock and Gore (2015)

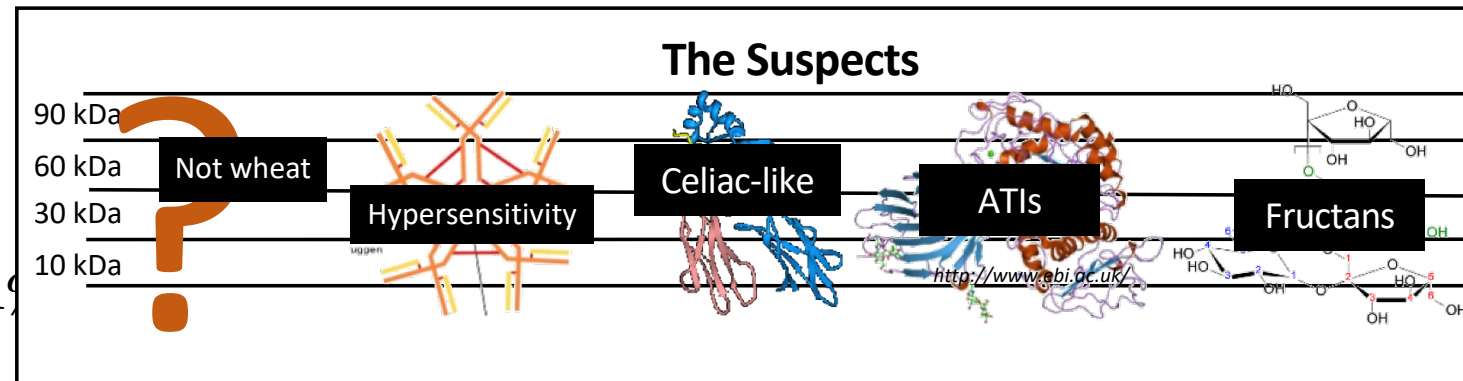


rediscover  goodness
OLDWAYS

Sensitivities to Wheat

Condition	Prevalence	Commonly potent reactive compounds in wheat	References
Celiac Disease	0.5-2%	α - and ω -gliadins, ATIs	(Rewers 2005; Tye-Din et al. 2010)
Wheat Allergy	0.2-0.5%	ATIs , LTPs, serpins, α - and ω -gliadins	(Zuidmeer et al. 2008; Vu et al. 2014)
Baker's Asthma		ATIs , LTPs, serpins, α - and ω -gliadins	(Sanchez-Monge et al. 1997; Sandiford et al. 1997)
Atopic Dermatitis		ATIs , LTPs, gliadins and glutenins	(Kusaba-Nakayama et al. 2000; Battais, Courcoux, et al. 2005)
Urticaria		ω -5 gliadin	(Battais, Courcoux, et al. 2005)
Anaphylaxis		ω -5 gliadin, LMW glutenin	(Battais, Courcoux, et al. 2005; Battais, Mothes, et al. 2005; Morita et al. 2009)

Non-celiac Wheat Sensitivity	0.55% ¹
Fructose Malabsorption	11-38% ¹
Irritable Bowel Syndrome	11.5-14.1% ¹

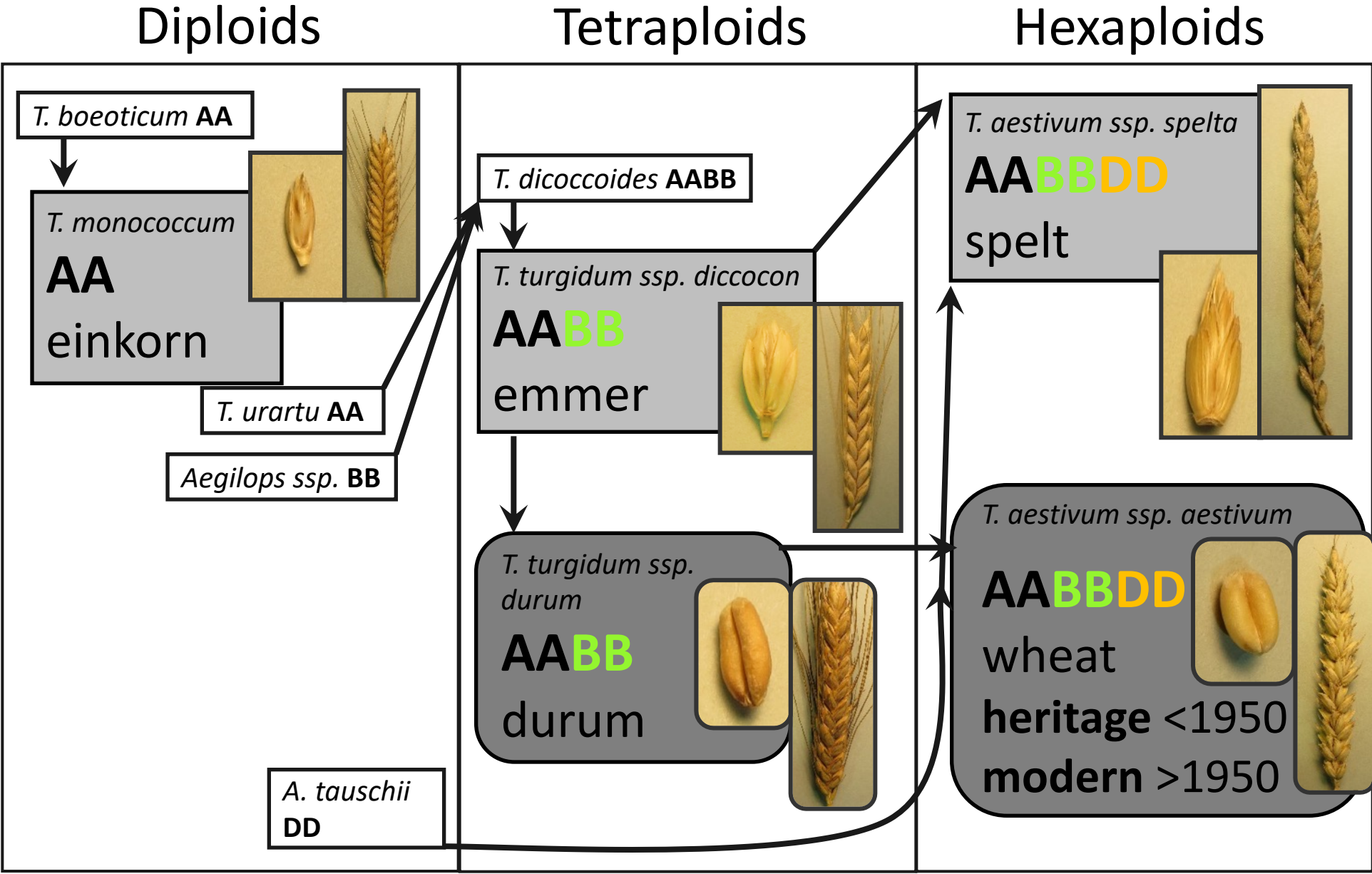


ATIs: amylase-trypsin inhibitors

LTPs: lipid transfer proteins

¹A large scale epidemiological study has not been conducted

The Wheat Family

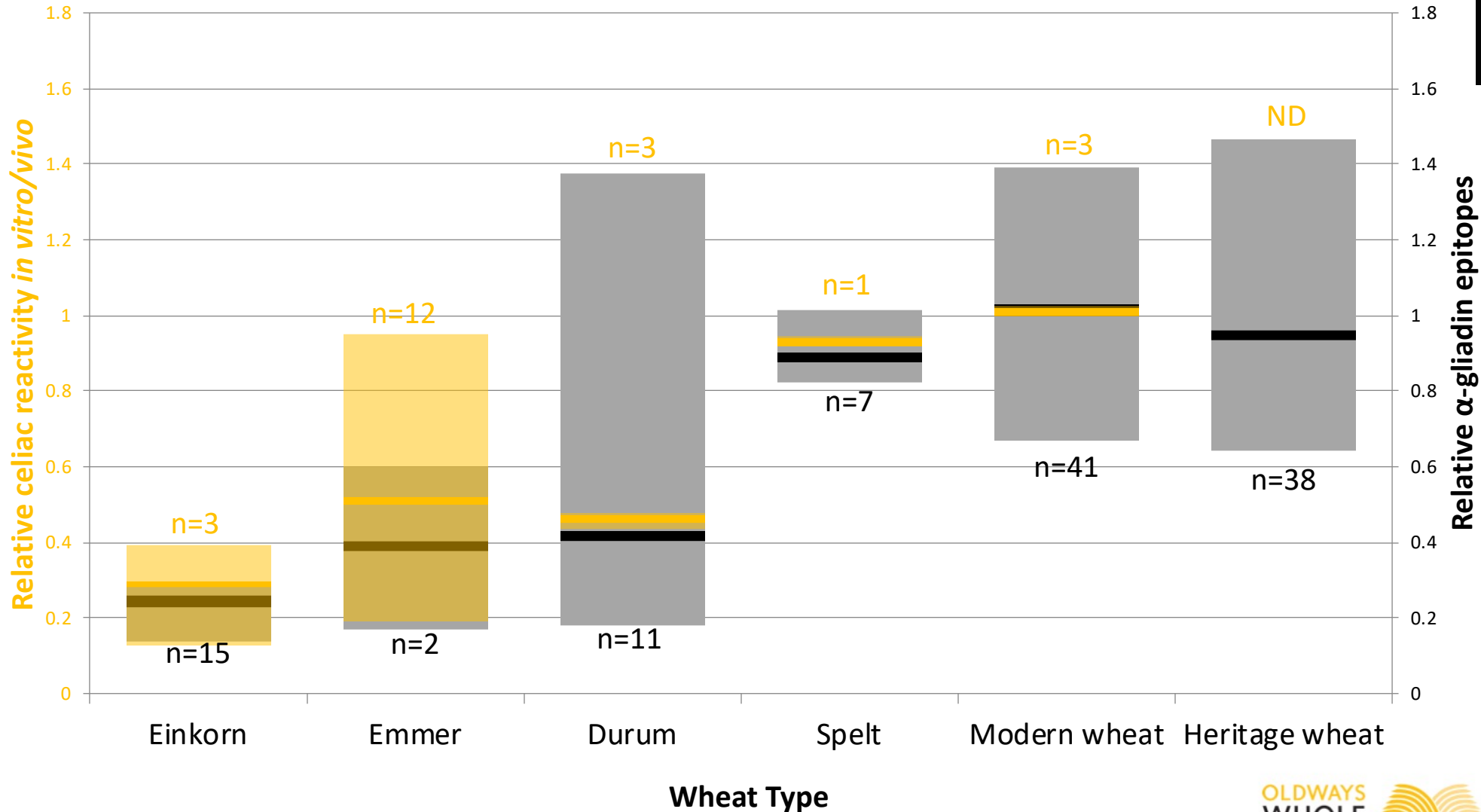
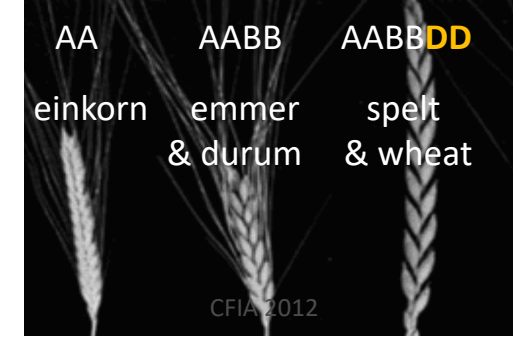


Key:

- Wild species
- Cultivated hulled species ("ancient wheat")
- Cultivated free-threshing species

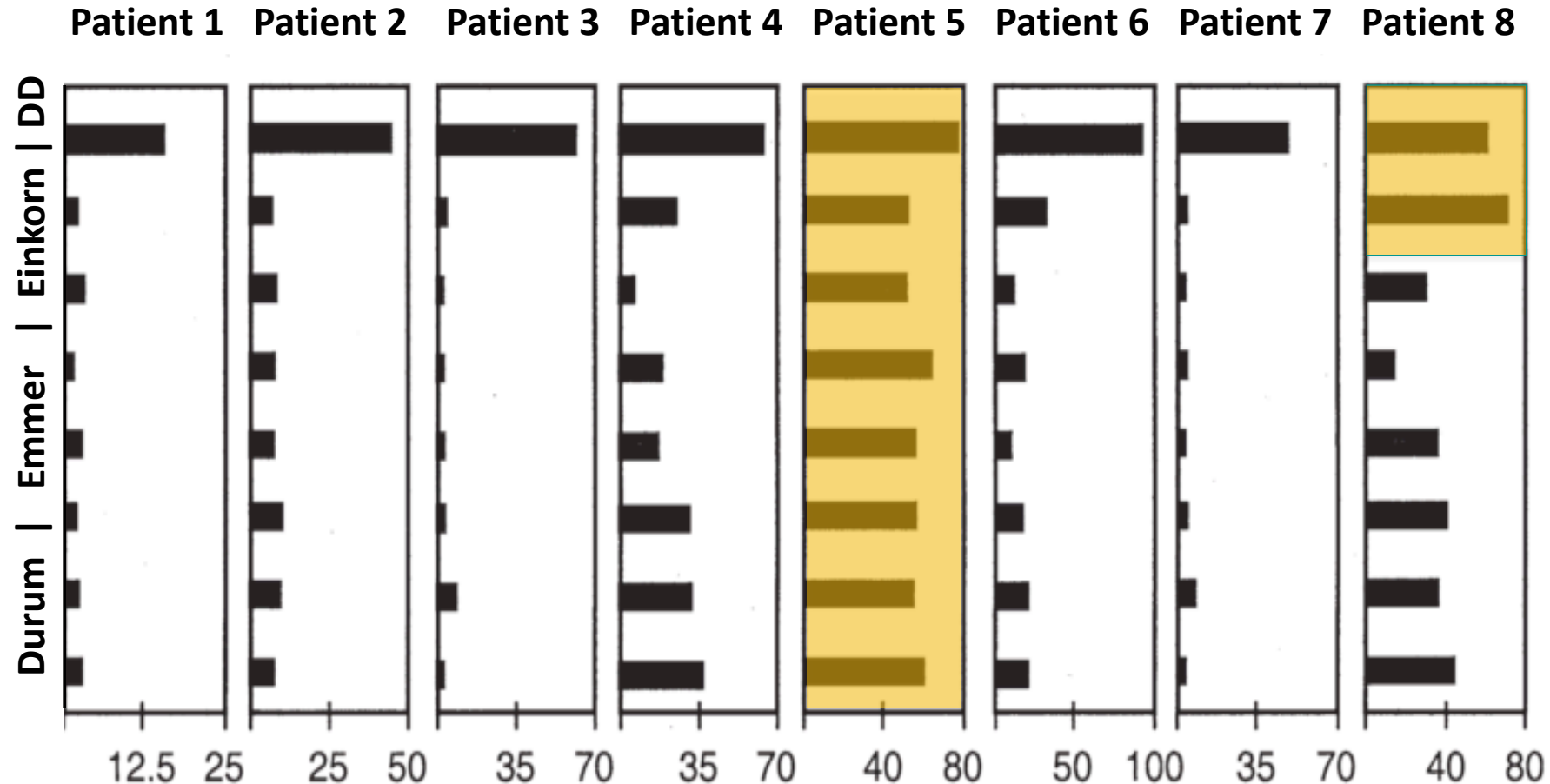
(Figure from Kissing Kucek et al. 2015, adapted from Dawson and others 2013).

Celiac Immunoreactivity



Meta-analysis of eight studies (Molberg et al. 2005; Pilloli et al. 2018; Pizzuti et al. 2006; Vincentini et al. 2007; Vincentini et al. 2009; van den Broeck, de Jong, et al. 2010; van den Broeck, Hongbing, et al. 2010). Max, min, and mean values (dark links) are presented. Labels "n=" refer to the number of unique varieties evaluated. Values were standardized by converting means for modern wheat in each study to 1.

Specificity of Reaction Varies by Patient

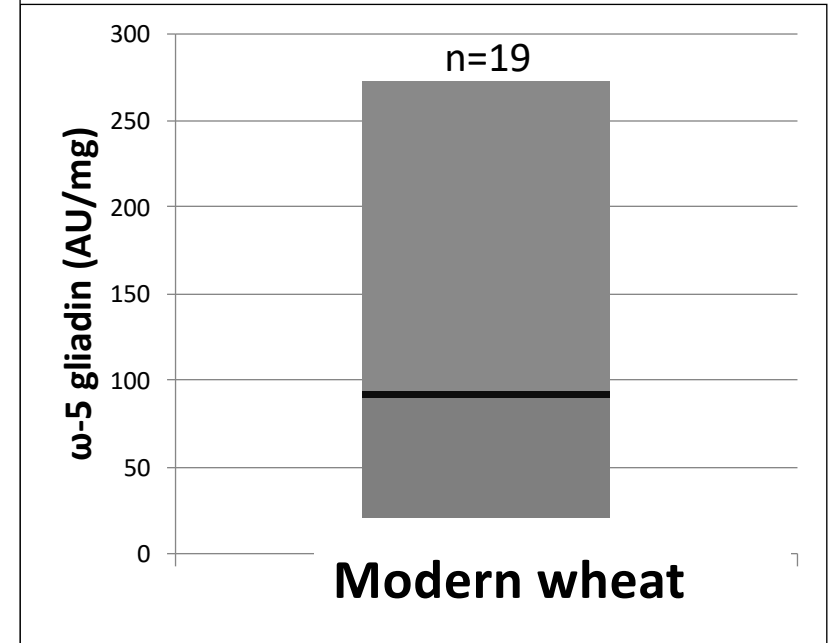
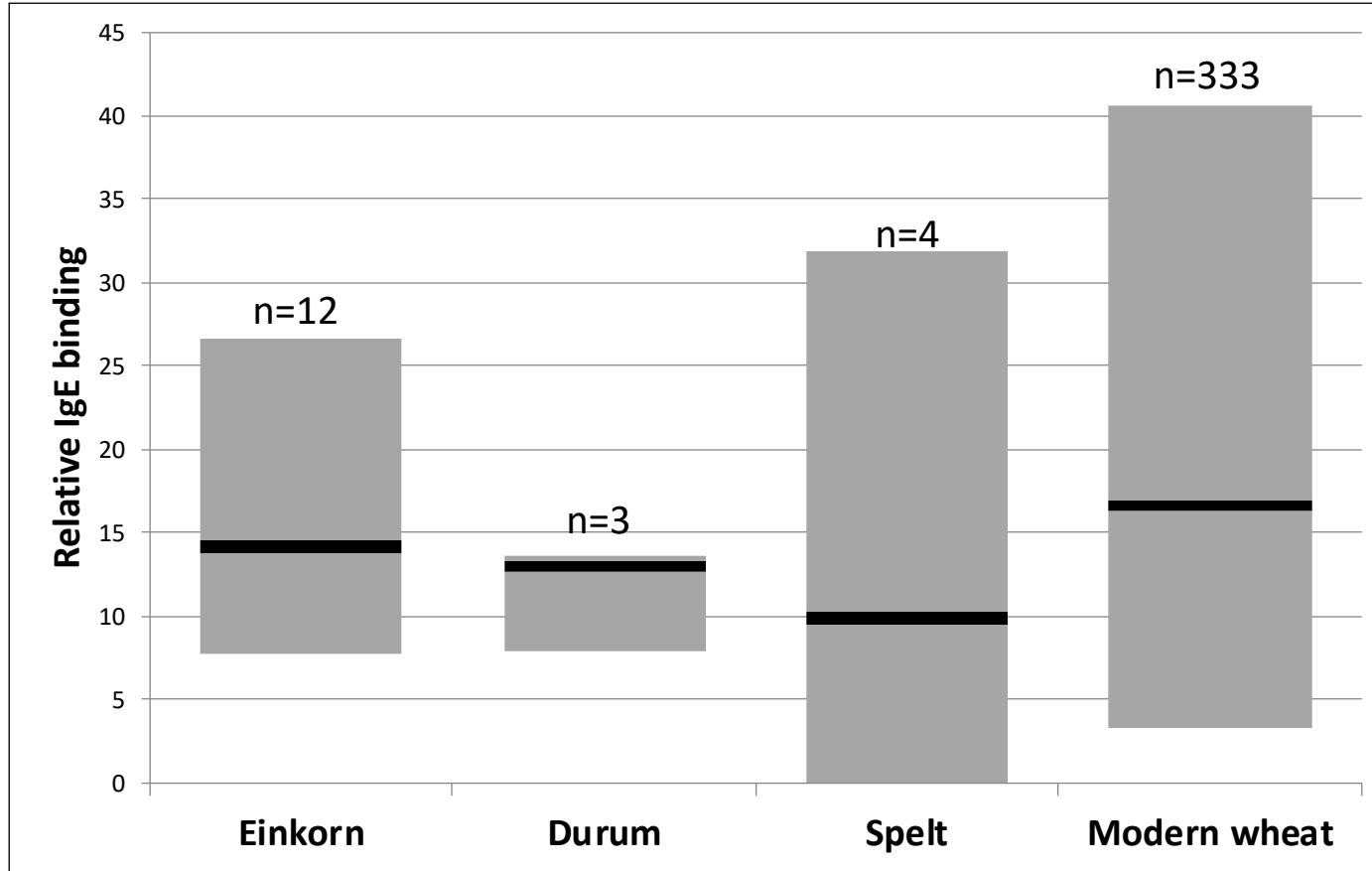
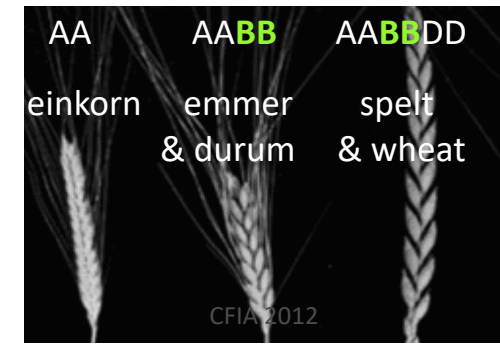


Reactivity Pattern of T-Cell Clones from Celiac Patients

Figure adapted from Molberg et al., 2005



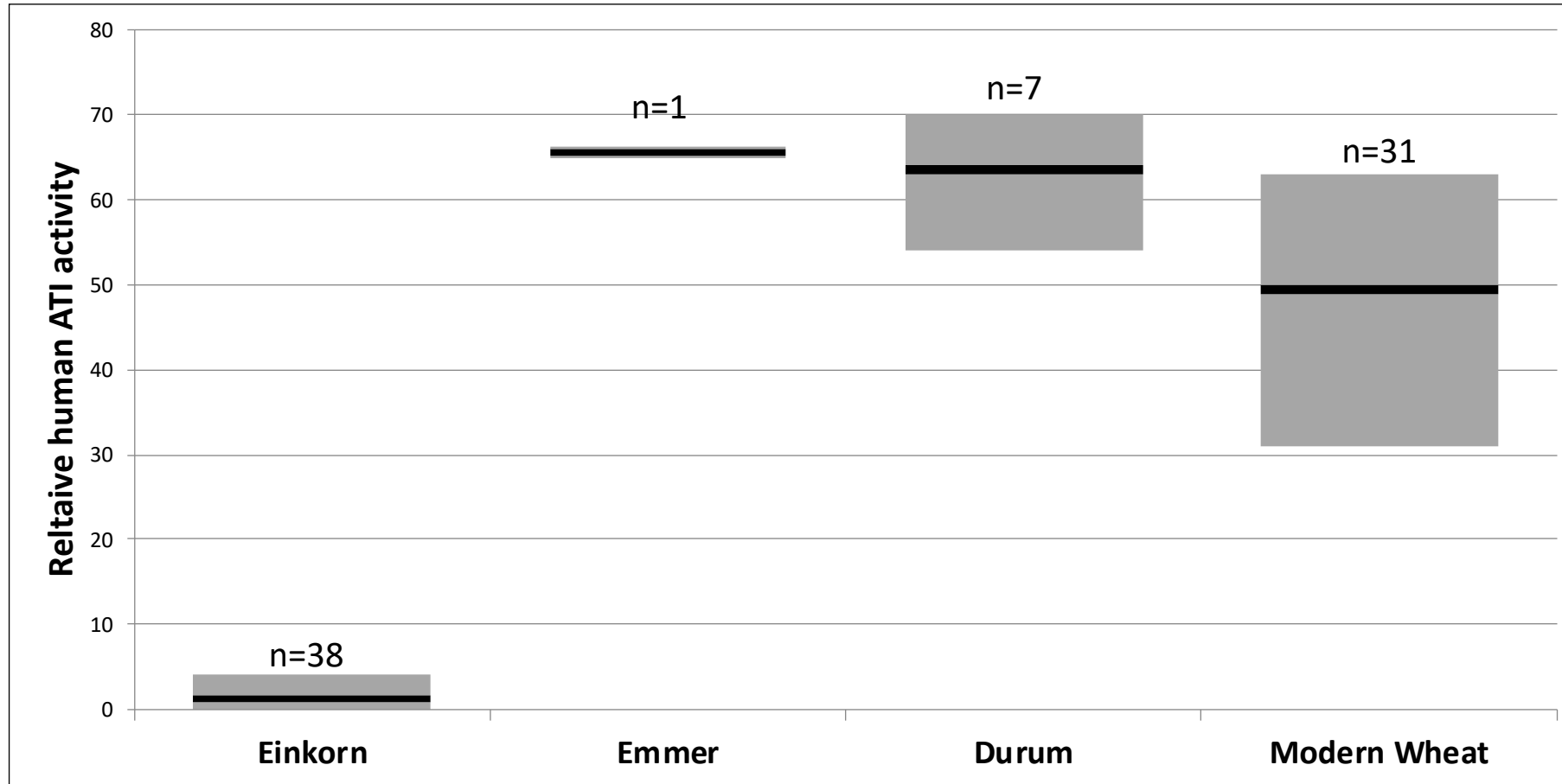
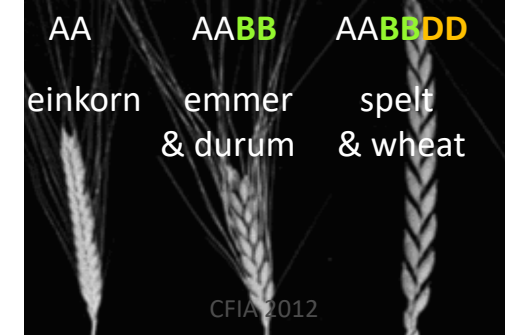
Allergenicity



Meta-analysis of eight studies (Weiss, Vogelmeier, and Gorg 1993; Sánchez-Monge et al. 1996; Klockenbring et al. 2001; Nakamura et al. 2005; Larré et al. 2011; Vu et al., 2014; Wieser et al. 1994; Wieser et al. 1998). Max, min, and mean values (black lines) are presented. Labels “n=” refer to the number of unique varieties evaluated. Values for IgE were normalized to a relative scale by converting reported average values for modern wheat in each study to a common value.

Amylase-Trypsin Inhibitors

(Celiac Disease, Wheat Allergy, and NCWS)



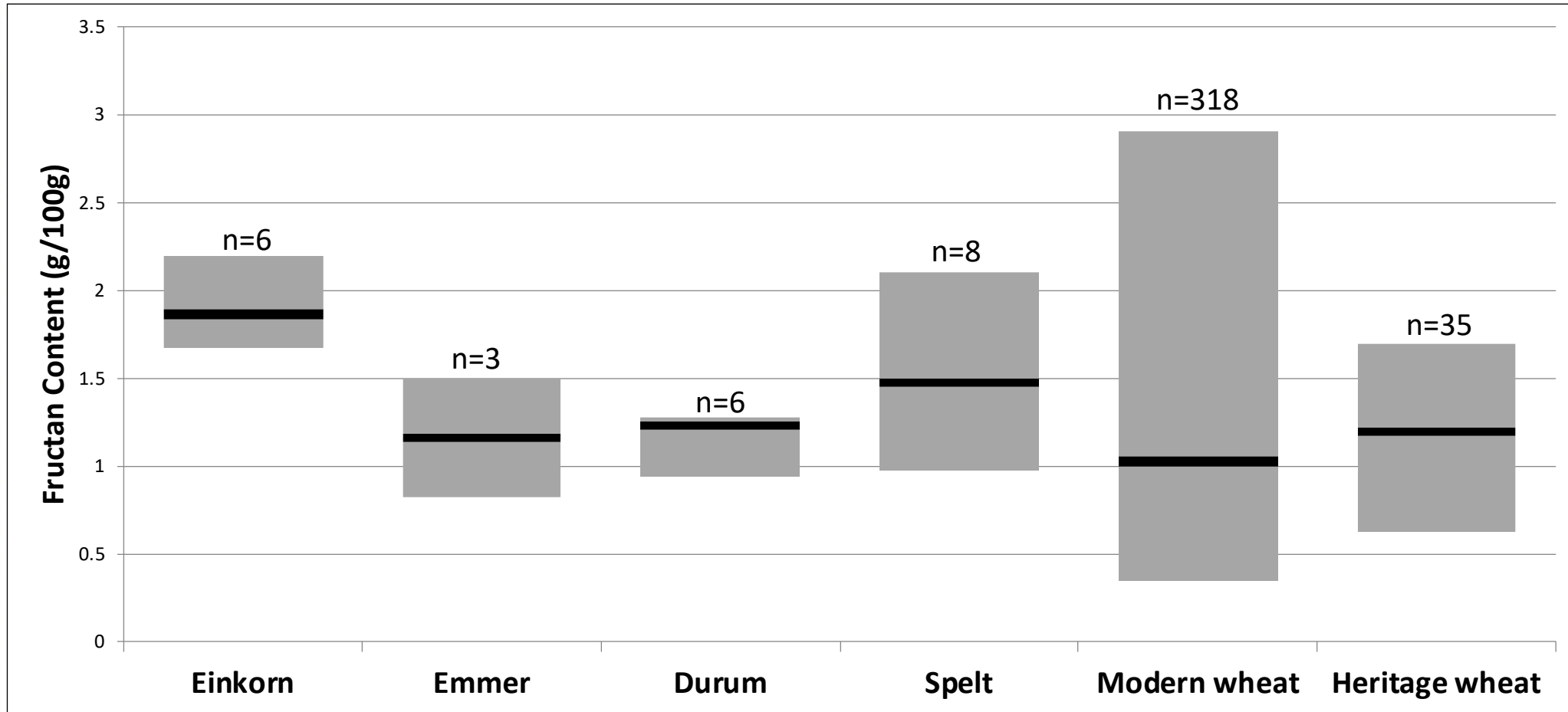
Meta-analysis of five studies (Bedetti et al. 1974; Vittozzi and Silano 1976; Sánchez-Monge et al. 1996; Wang et al. 2007; Zoccatelli et al. 2012). Max, min, and mean (black lines) values presented. Labels “n=” refer to the number of unique varieties evaluated. Values for ATIs were normalized to a relative scale by converting reported average values for modern wheat in each study to a common value.

Fructans

(Fructose Malabsorption, IBS, and NCWS)



Lynn Veenstra



Meta-analysis of nine studies (De Gara et al. 2003; Fretzdorff and Welge (2003); Gelinas et al. (2015); Huynh et al. 2008; Brandolini et al. 2011; Hammed 2014; Veenstra 2014; Verspreet et al. (2012); Ziegler et al. 2016). Max, min, and mean (black lines) values presented. Labels “n=” refer to the number of unique varieties evaluated. Values for ATIs were normalized to a relative scale by converting reported average values for modern wheat in each study to a common value.



From Varieties to Flour

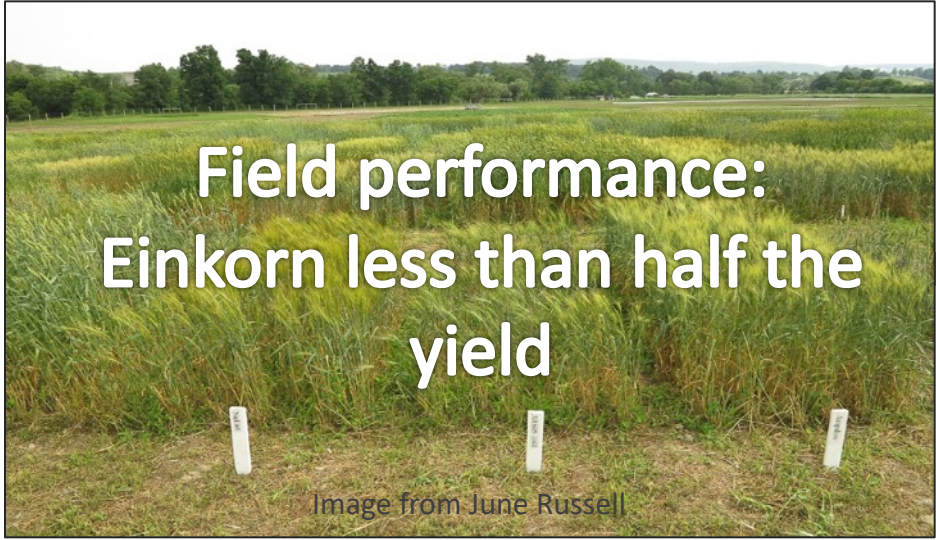
ω -5 gliadins	ATIs	Fructans?
----------------------	------	-----------

Euphytica (2014) 195:105–116
DOI 10.1007/s10681-013-0984-1

Development and characteristics of ω -gliadin-free wheat genotypes



[Photo by: pink hats, red shoes](#)





Veganbaking.net (cropped)

Processing Method

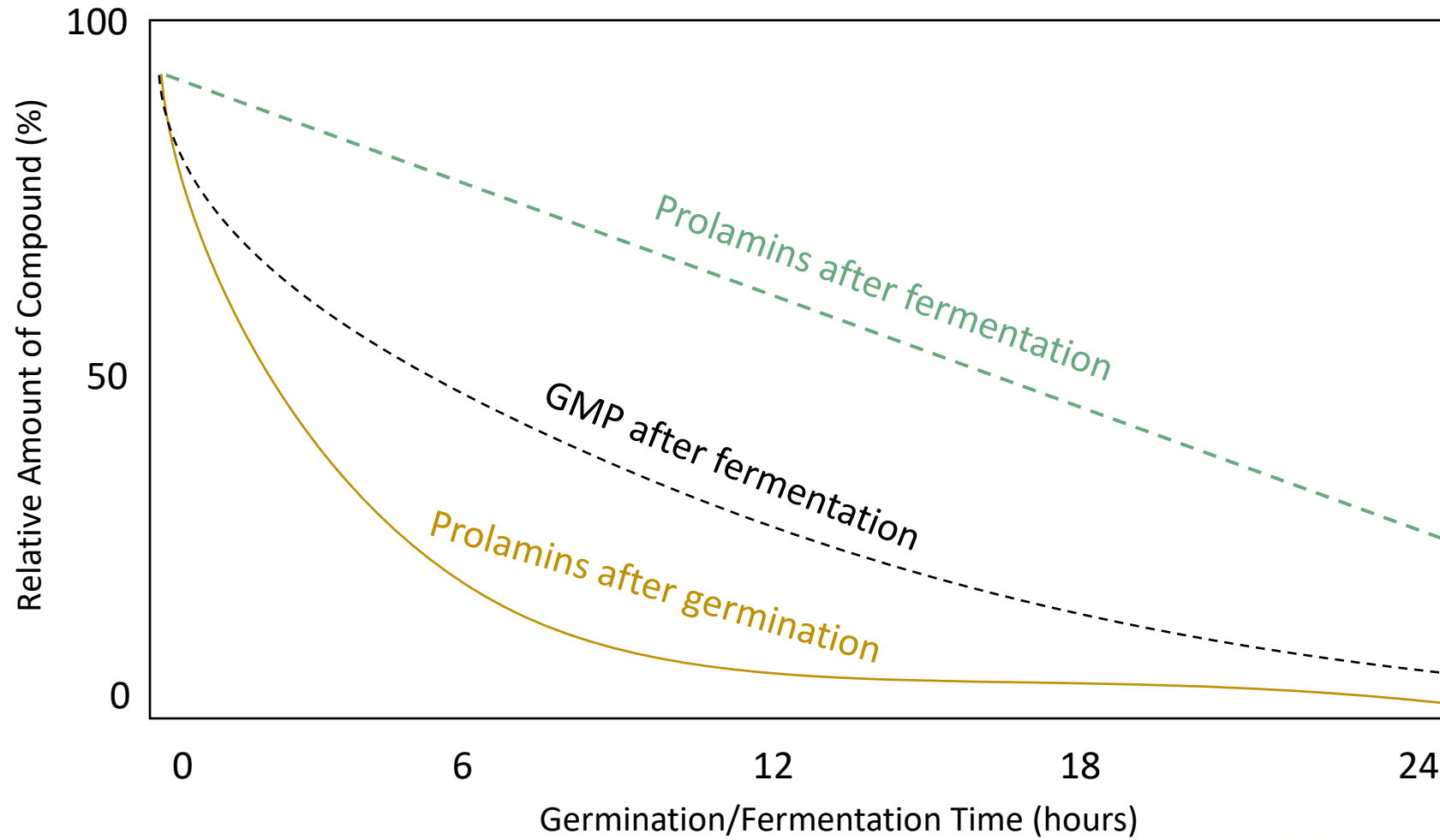
Impacts on Wheat Sensitivity



Allison Usavage © 2014

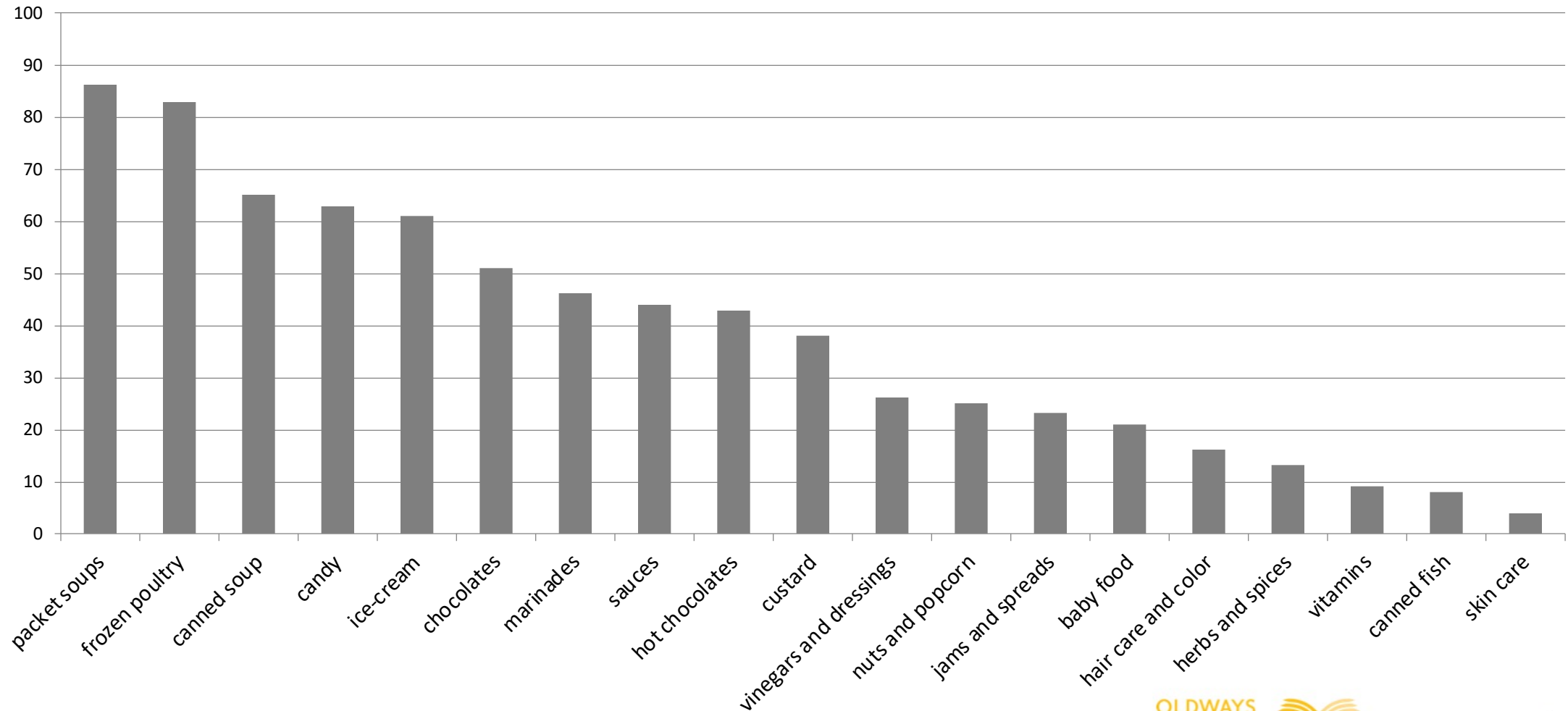


Germination and Fermentation



Food Additives and Supplements

Grocery Survey: % Products in a Category Containing Wheat



Data from Atchison et al., 2010



Conclusions

- **Understand what is causing sensitivities first.**
- **No wheat is safe for celiac disease.**
- **To reduce accidental exposure and delay disease epidemiology:**
 - Select wheat genotypes with low reactivity for specific conditions (get tested first);
 - Use germination and fermentation processes;
 - Avoid Vital Wheat Gluten, isolated wheat protein, and/or inulin.

References and Acknowledgements

- Atchison, J., Head, L., & Gates, A. (2010). *Geoforum*, 41(2), 236–246.
- Bedetti, C., Bozzini, A., Silano, V., & Vittozzi, L. (1974). *Bichimica et Biophysica Acta*, 362, 299–307.
- Brandolini, A., Hidalgo, A., Plizzari, L., & Erba, D. (2011). *Journal of Cereal Science*, 53(1), 65–72.
- Buonocore, V., Petrucci, T., & Silano, V. (1977). *Phytochemistry*, 16, 811–820.
- Carroccio, A., Mansueto, P., Iacono, G., Soresi, M., D'Alcamo, A., Cavataio, F., ... Rini, G. B. (2012). *The American Journal of Gastroenterology*, 107(12), 1898–906
- CFIA. 2012. Spike and Spikelet Characteristics of Einkorn, Emmer and Spelt. Available online at <http://www.inspection.gc.ca/plants/seeds/inspection-procedures/cereal-crops/eng/1347203083351/1347203347397>
- Davis W. 2011. Wheat Belly: Lose the Wheat, Lose the Weight, and Find Your Path Back to Health. Rodale
- Dawson, Julie. 2013. The “Ancient” Grains Emmer, Einkorn, and Spelt: What we know and what we need to find out. eOrganic webinar.
- De Gara, L., de Pinto, M. C., Moliterni, V. M. C., & D'Egidio, M. G. (2003). *Journal of Experimental Botany*, 54(381), 249–258.
- Fretzdorff, B., & Welge, N. (2003b). Fructan- und Raffinosegehalte im Vollkorn einiger Getreidearten und Pseudo-Cerealien. *Getreide, Mehl und Brot*, 57, 3–8.
- Gélinas, P., McKinnon, C., & Gagnon, F. (2015). Fructans, watersoluble fibre and fermentable sugars in bread and pasta made with ancient and modern wheat. *International Journal of Food Science & Technology*, doi:10.1111/ijfs.13022
- Hammed, A. (2014). *Cereal Chemistry*, 91(2), 97–104.
- Huynh, B.-L., Palmer, L., Mather, D. E., Wallwork, H., Graham, R. D., Welch, R. M., & Stangoulis, J. C. R. (2008). *Journal of Cereal Science*, 48(2), 369–378.
- Klockenbring, T., Boese, a., Bauer, R., & Goerlich, R. (2001). *Food and Agricultural Immunology*, 13(3), 171–181.
- Larré, C., Lupi, R., Gombaud, G., Brossard, C., Branlard, G., Moneret-Vautrin, D. a, ... Denery-Papini, S. (2011). *Journal of Proteomics*, 74(8), 1279–89.
- Mercier, Florent. 2008. Voyage autour des blés paysans. Voyage autour des blés paysans
- Molberg, Ø., Uhlen, A. K., Jensen, T., Flæte, N. S., Fleckenstein, B., Arentz-Hansen, H., ... Sollid, L. M. (2005). *Gastroenterology*, 128(2), 393–401.
- Nakamura, A., Tanabe, S., Watanabe, J., Makino, T., Station, A. E., & April, R. (2005). *Journal of Nutritional Science and Vitaminology*, 51, 204–206.
- National Association of Wheat Growers. 2013. Nutrition. Wheat Info:1. [accessed 2014 Jan 5]. <http://www.wheatworld.org/wheat-info/nutrition/>
- Pilloli, R, A. Gadaleta, G. Mamone, D. Nigro, E. De Angelis, M. Montemurro, L. Monaci. 2018. Scouting for Naturally Low-Toxicity Wheat Genotypes by a Multidisciplinary Approach. *Scientific Reports*, 9, 1646.
- Pizzuti, D., Buda, A., D'Odorico, A., D'Incà, R., Chiarelli, S., Curioni, A., & Martines, D. (2006). *Scandinavian Journal of Gastroenterology*, 41(11), 1305–11.
- Sánchez-Monge, R., García-Casado, G., Malpica, J. M., & Salcedo, G. (1996). *TAG. Theoretical and Applied Genetics. Theoretische Und Angewandte Genetik*, 93(5-6), 745–50.
- Skodje, G.I, V.K. Sarna, I.H. Minelle, K.L. Rolfsen, J.G. Muir, P.R. Gibson, M.B. Veierod, C. Henriksen, K.E.A. Lundin. Fructan, rather than gluten, induces symptoms in patients with self-reported non-celiac gluten sensitivity. *Gastroenterology*, 154, 529-539.
- Van den Broeck, H. C., de Jong, H. C., ... Smulders, M. J. M. (2010). *TAG. Theoretical and Applied Genetics. Theoretische Und Angewandte Genetik*, 121(8), 1527–39.
- Van den Broeck, H. C., Hongbing, C., Lacaze, X., Dusautoir, J.-C., Gilissen, L., Smulders, M., & van der Meer, I. (2010). *Molecular Biosystems*, 6(11), 2206–13.
- Veenstra, L. (2014). [Fructan contents of a diverse set of winter wheat varieties]. Unpublished raw data.
- Vincentini, O., Borrelli, O., Silano, M., Gazza, L., Pogna, N., Luchetti, R., & De Vincenzi, M. (2009). *Clinical Nutrition (Edinburgh, Scotland)*, 28(3), 272–7.
- Vincentini, O., Maialetti, F., Gazza, L., Silano, M., Dessi, M., De Vincenzi, M., & Pogna, N. E. (2007). *Journal of Gastroenterology and Hepatology*, 22(11), 1816–22.
- Vittozzi, L., & Silano, V. (1976). *TAG. Theoretical and Applied Genetics. Theoretische Und Angewandte Genetik*, 48(6), 279–84. doi:10.1007/BF00264959
- Vu, N. T., Chin, J., Pasco, J. a., Kovács, A., Wing, L. W., Békés, F., & Suter, D. a. I. (2014). *Cereal Research Communications*, 1, 1–11.
- Wang, J.-R., Zhang, L., Wei, Y.-M., Yan, Z.-H., Baum, B. R., Nevo, E., & Zheng, Y.-L. (2007). *Plant Science*, 173(1), 1–11
- Weiss, W., Vogelmeier, C., & Gorg, A. (1993). *Electrophoresis*, 14, 805–816.
- Verspreet, J., Pollet, A., Cuyvers, S., Vergauwen, R., van den Ende, W., Delcour, J. A., & Courtin, C. M. (2012). A simple and accurate method for determining wheat grain fructan content and average degree of polymerization. *Journal of Agricultural and Food Chemistry*, 60, 2102–2107.
- Zoccatelli, G., Sega, M., Bolla, M., Cecconi, D., Vaccino, P., Rizzi, C., ... Brandolini, A. (2012). *Food Chemistry*, 135(4), 2643–9.
- Ziegler, J.U., D. Steiner, C.F.H. Longin, T. Wurschum, R.M. Schweiggert, R. Carle. 2016. *Journal of Functional Foods*, 25, 257-266.
- Thanks to A. Kovacs for sharing supplemental data from Vu et al., 2014.

