Ancient, ancestral, heritage, and modern... the whole nine grains...

Dr. Andrew Ross

September 26, 2023

Disclosures

- There was **no commercial support** provided for this webinar.
- This webinar was organized by Oldways, the 501(c)3 nutrition education nonprofit that founded and runs the Oldways Whole Grains Council.

Ancient, ancestral, heritage, pseudo, and modern: the whole nine grains…

Andrew Ross

Oregon State University

Oldways Webinar 2023

Photo: Christiana Vallejos

Funding disclosure

- Cereal Quality Lab Operating: Oregon Wheat Commission
- Acrylamide potential in Oregon soft wheats: Oregon Wheat Commission
- Measuring amylases and their effects in wheat: USDA
- Whole grain naked barley for food: USDA AFRI OREI

- Research Bakery Rebuild
  - OSU College of Agricultural Sciences (CAS) Building Use Credits
  - American Rescue Plan Act
  - Oregon Wheat Commission
  - Fax Family Endowment
  - Bay State Milling
  - Wheat Marketing Center
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  - Hatch Funds - Plant Breeding and Genetics Project (shelving)

Cormac McCarthy's three things

- Wholegrains are good for you.

- Wholegrains are superior nutritionally to refined grains.

- Eat a diverse array of wholegrains - ancient, ancestral, heritage, pseudo, or modern to help maintain your gut microbe diversity.

- Savage, V. and Yeh, P., 2019. Novelist Cormac McCarthy's tips on how to write a great science paper. Nature, 574(7777), pp.441-443.

Wholegrains and health

*"[Less than] *5% of Americans meet the recommended intake for dietary fiber, and the magnitude of the gap is large, approximately a 50–70% shortfall…*

…the fiber gap represents an opportune target at which dietary interventions can be directed".

*Thompson HJ, Brick MA. Perspective: Closing the Dietary Fiber Gap: An Ancient Solution for a 21st Century Problem. Adv Nutr. 2016 Jul 15;7(4):623-6. doi: 10.3945/an.115.009696. PMID: 27422499; PMCID: PMC4942856.

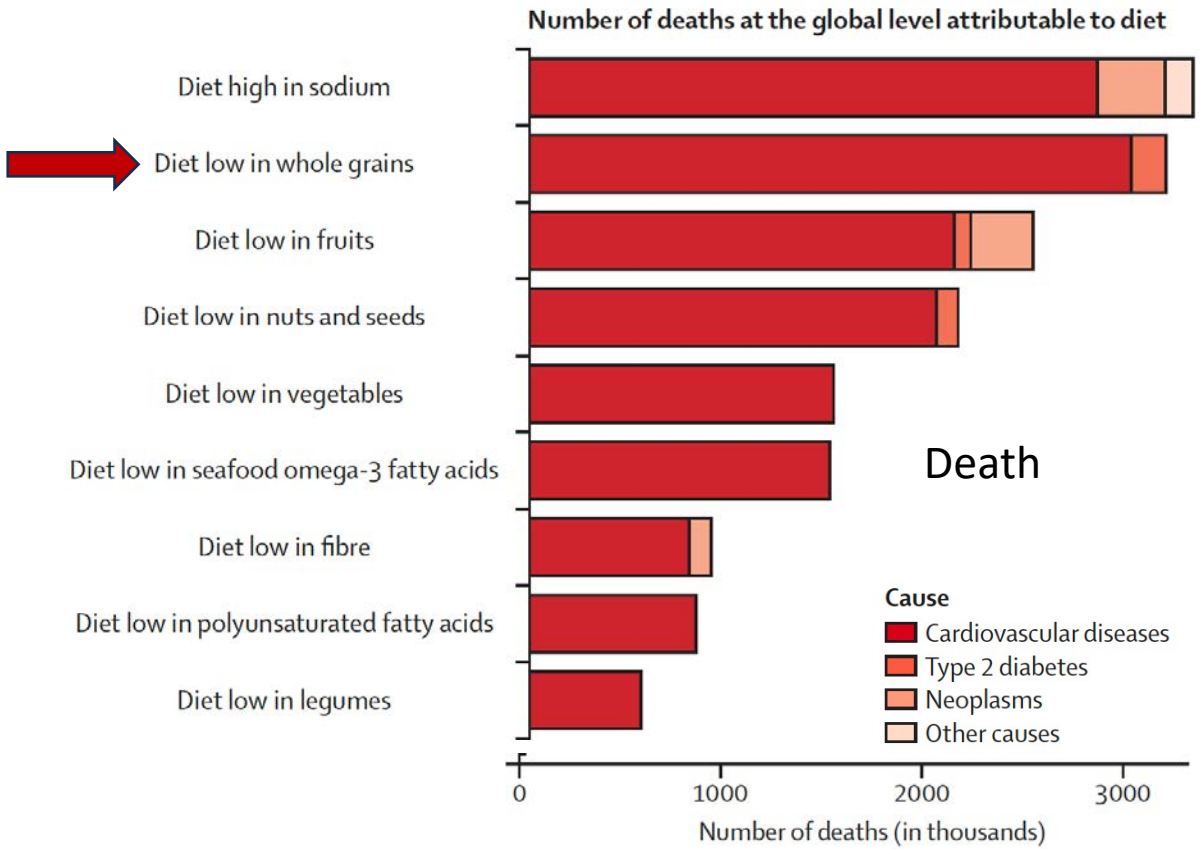
Why whole grains

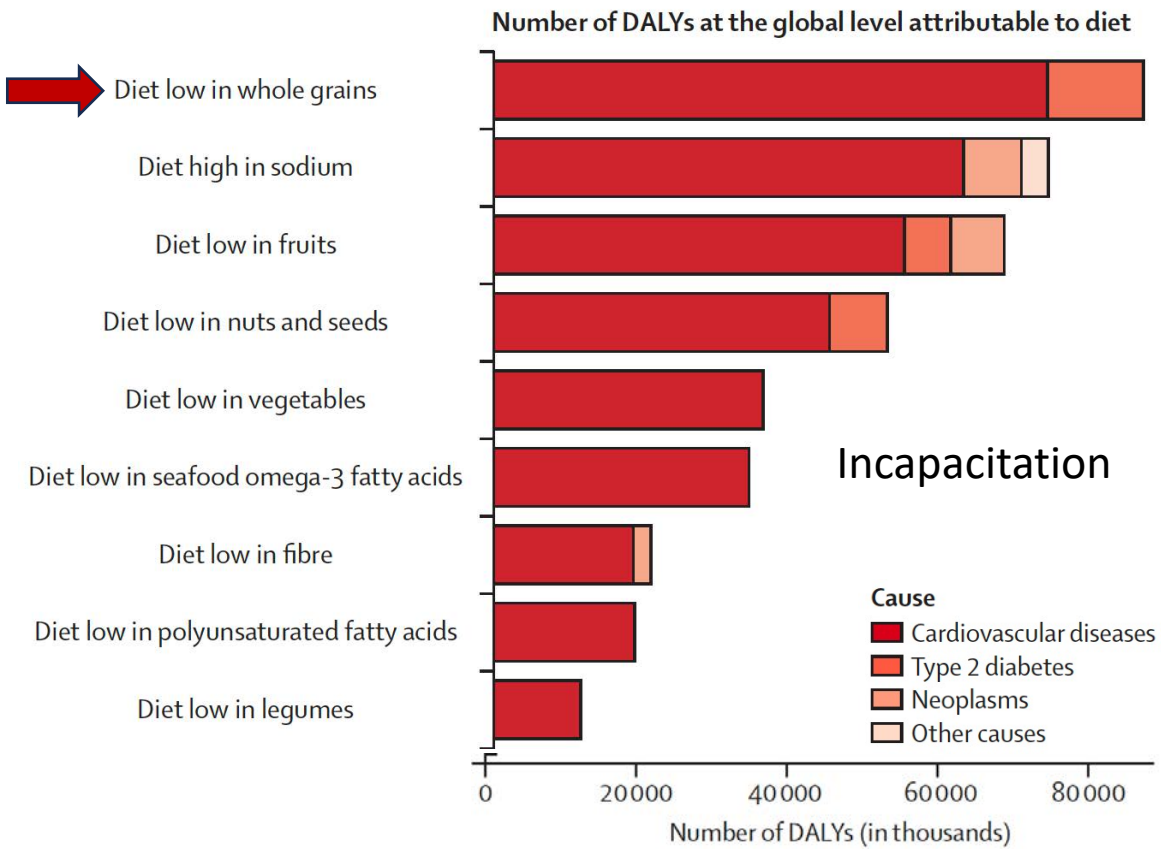
- Superior contributions to human wellbeing.
  - A convenient and synergistic way of addressing the fiber gap.
  - Contribute big MACs and therefore colonic SFCAs.

- Habitual consumption of whole grains:
  - Increased longevity
  - Increased active lifespan
  - Reduced incidence of cardiovascular diseases, Type 2 Diabetes, & colorectal cancers.
  - Improved gut health
  - Improved microbiome health and diversity.
  - Fecal regularity

Health effects of dietary risks in 195 countries, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017

*GBD 2017 Diet Collaborators**





Afshin, A., Sur, P.J., Fay, K.A., Cornaby, L., Ferrara, G., Salama, J.S., Mullany, E.C., Abate, K.H., Abbafati, C., Abebe, Z. and Afarideh, M., 2019. Health effects of dietary risks in 195 countries, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017. The Lancet.

Delaying the onset of senescence…

- *"…improving life expectancy is not enough…*
- *[only improving life **expectancy**] predicts in current circumstances [just] an increased number of years in poor health".*

All's well that ages well: The economic value of targeting ageing. Martin Ellison, Andrew Scott, David A. Sinclair 11 August 2021. https://voxeu.org/article/economic-value-targeting-ageing

- "[Ellison et al's] *An intervention* that delays ageing such that life expectancy increases by one year (and health improves too) is worth $38 trillion [each year]…*" in the USA alone.

*metformin

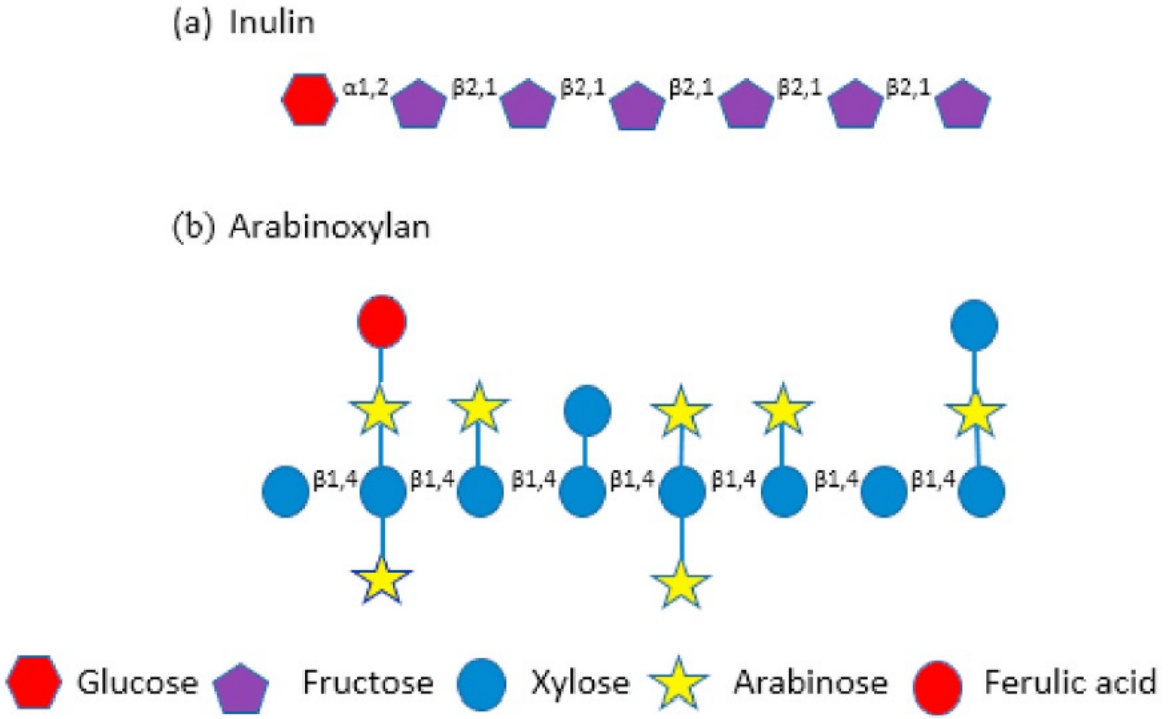
Common fiber types in cereal grains.

-Arabinoxylans and xylo-oligosaccharides
-Beta glucan
-Fructans and fructo-oligosaccharides
-Galctooligosaccharides
-Resistant starch

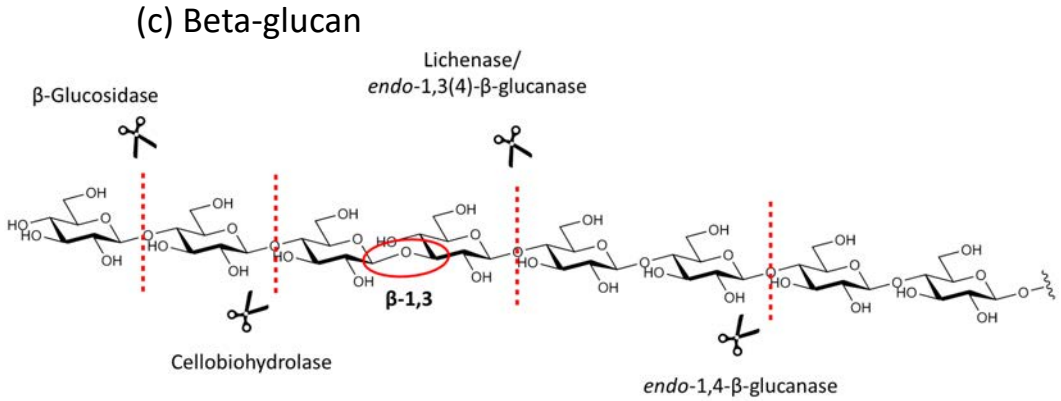
These are often *microbiota accessible carbohydrates* (big MACs). Soluble OR insoluble forms.

Sonnenburg, Erica.D. and Sonnenburg, Justin.L., 2014. Starving our microbial self: the deleterious consequences of a diet deficient in microbiota-accessible carbohydrates. Cell metabolism, 20(5), pp.779-786.

Sonnenburg, J. and Sonnenburg, E., 2016. The good gut: Taking control of your weight, your mood, and your long-term health. Penguin Books.



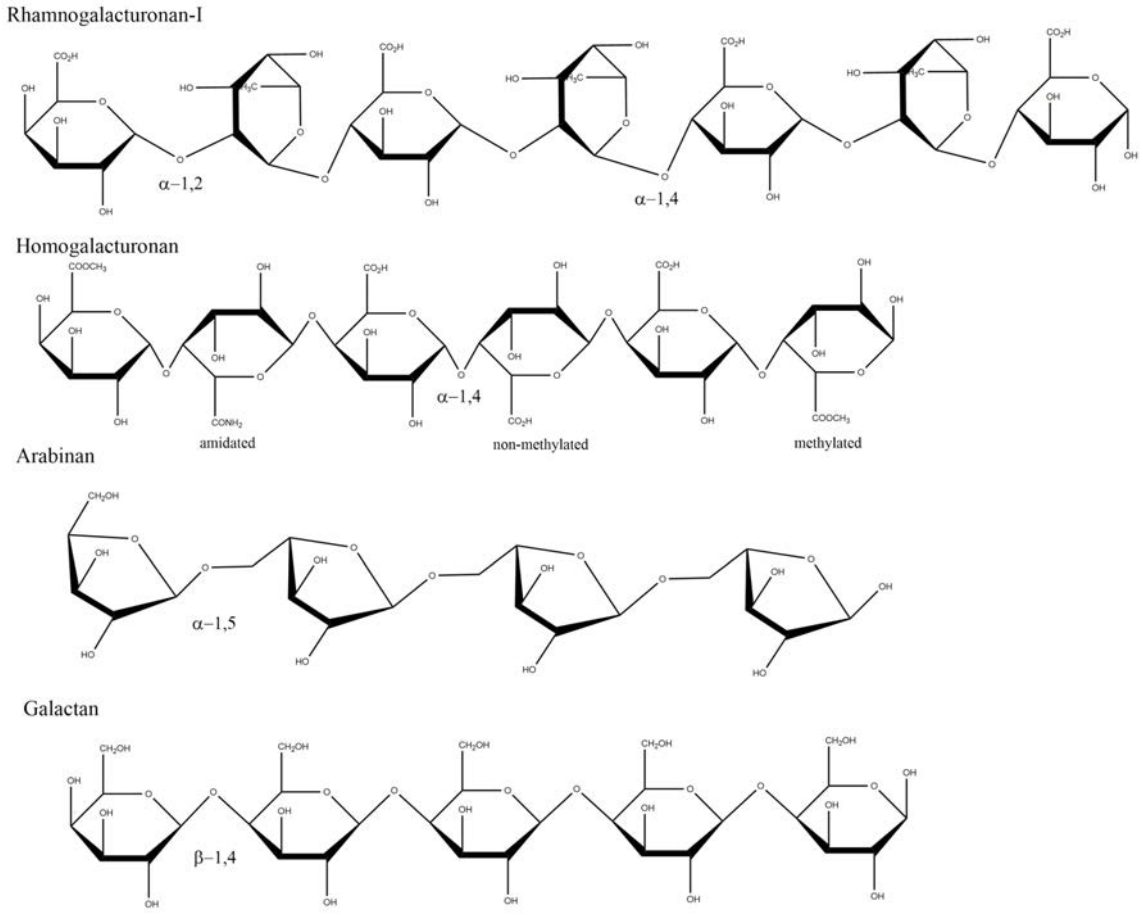
Ayua, E.O., Kazem, A.E. and Hamaker, B.R., 2020. Whole grain cereal fibers and their support of the gut commensal Clostridia for health. Bioactive Carbohydrates and Dietary Fibre, 24, p.100245.



Quinoa, amaranth, buckwheat

Fiber polysaccharides of the dicot pseudocereals are rich in pectins and xyloglucans.

The polysaccharide composition[s] of the 3 pseudocereal grains are more like fruits and vegetables than they are like cereals.

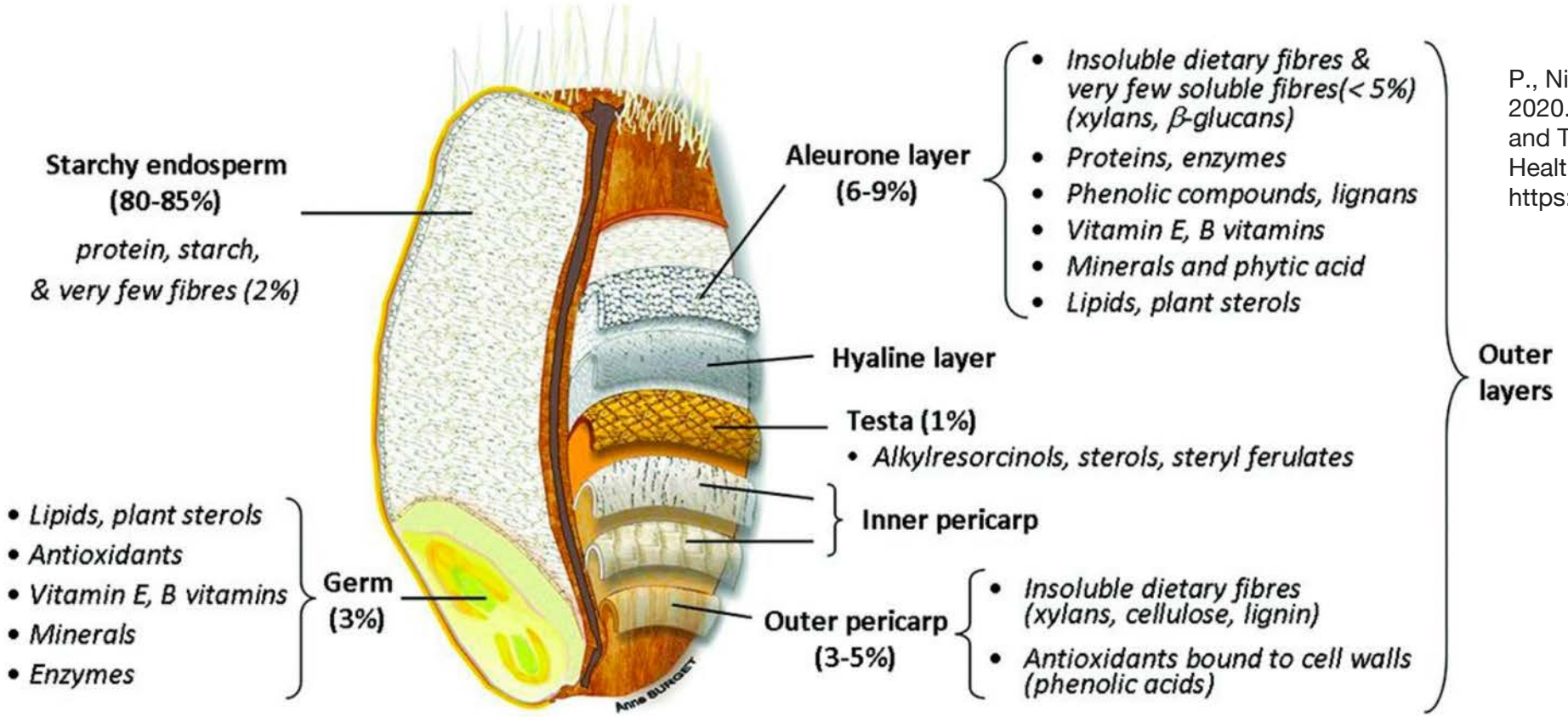


- Zhu, F., 2020. Dietary fiber polysaccharides of amaranth, buckwheat and quinoa grains: A review of chemical structure, biological functions and food uses. *Carbohydrate Polymers*, *248*, p.116819.

- P., Nirmala Prasadi V., and Iris J. Joye. 2020. "Dietary Fibre from Whole Grains and Their Benefits on Metabolic Health" Nutrients 12, no. 10: 3045. https://doi.org/10.3390/nu12103045

- Pedrosa LdF, Nascimento KR, Soares CG, Oliveira DPd, de Vos P, Fabi JP.2023. "Unveiling Plant-Based Pectins: Exploring the Interplay of Direct Effects, Fermentation, and Technological Applications in Clinical Research with a Focus on the Chemical Structure" Plants 12, no. 14: 2750. https://doi.org/10.3390/plants12142750

Micronutrients are commonly co-located with the fiber and may be the key difference between eating the whole grain, as opposed to refined fiber fractions:



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FIBER: direct effects

Soluble fiber: direct effects

viscosity and glycemia

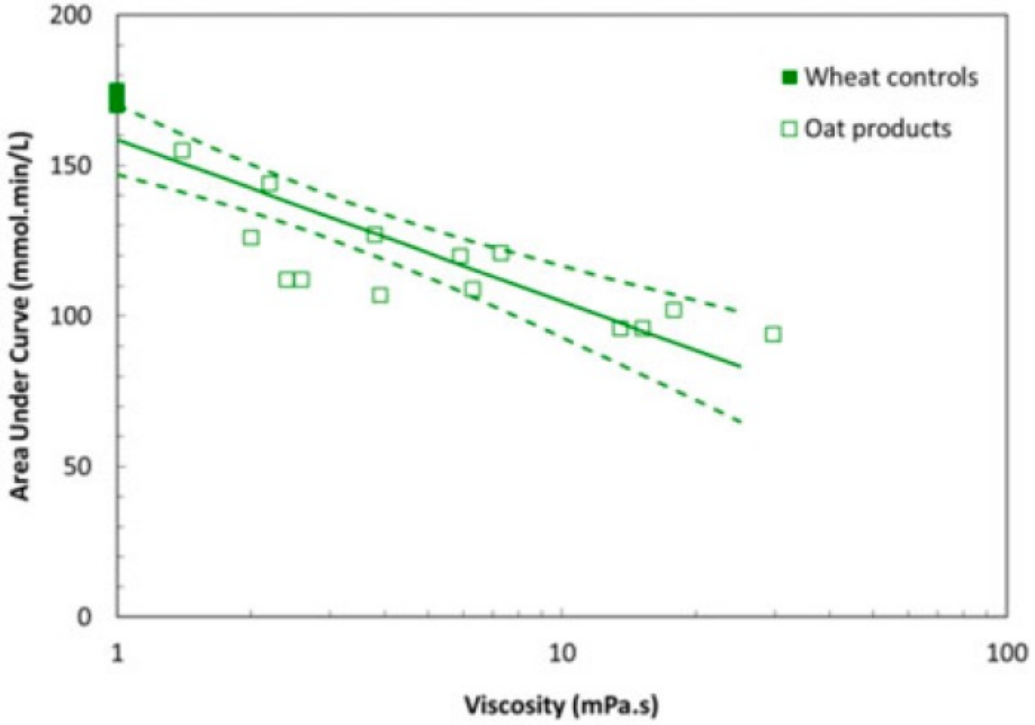
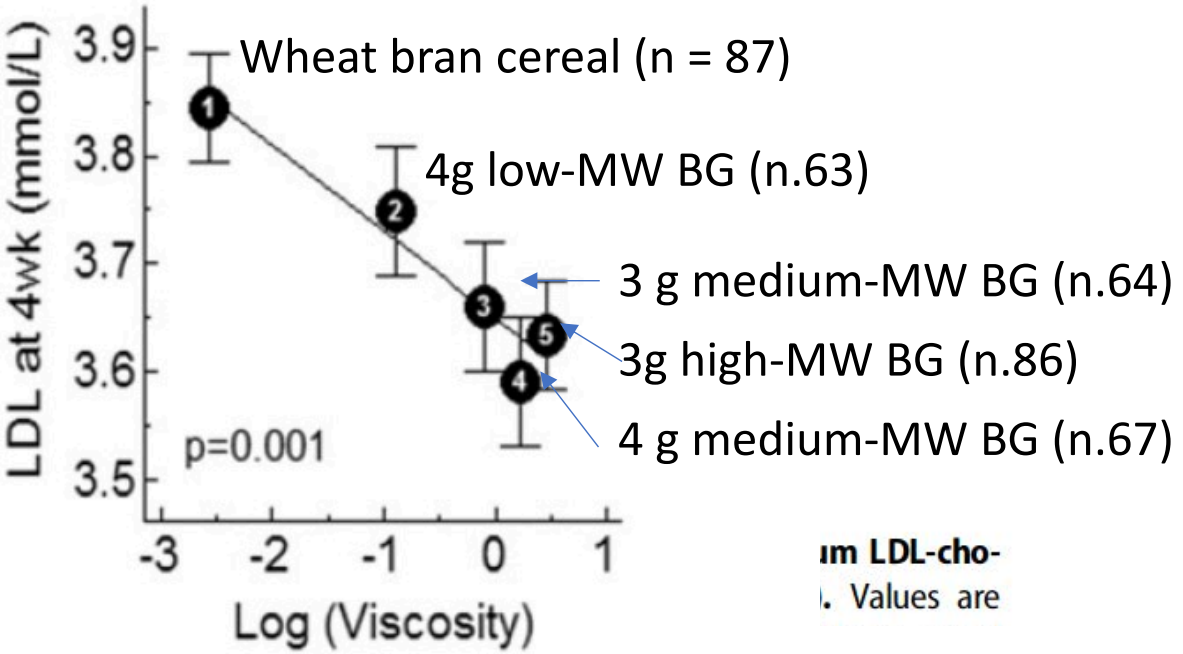


Figure 3 **Relationship between glycemic responses of human subjects (AUC of the postprandial blood glucose curve) and the apparent viscosity (at 30 mPa·s) of the β-glucan extracted by simulated digestion.** AUC $= -25 \log(\eta) + 134$ ($r^2 = 0.85$). Adapted from Tosh (2013)[26] *Abbreviations*: AUC, area under the curve.

viscosity and cholesterolemia



Tosh, S.M. and Bordenave, N., 2020. Emerging science on benefits of whole grain oat and barley and their soluble dietary fibers for heart health, glycemic response, and gut microbiota. Nutrition Reviews, 78 (Supplement_1), pp.13-20.

Insoluble fiber: direct effects

Insoluble fiber…
-promotes regularity

-increases colonic transit speed via irritation of gut mucosa and stimulation of peristalsis. Increases stool frequency.

"*Large, coarse particles providing greater laxative efficacy than fine, smooth particles*".

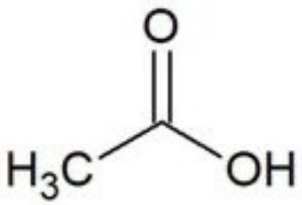
Soluble fiber also increases fecal bulk and water content – increases fecal bacterial count, increases stool frequency but can induce bloating and gas retention.

Cummings JH. The effect of dietary fiber on fecal weight and composition. In: Spiller G, ed. Dietary Fiber in Human Nutrition. Boca Raton, FL: CRC Press; 2001:183–252.

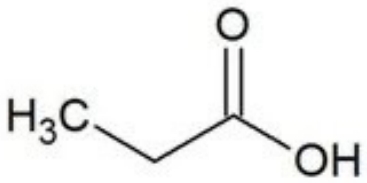
Eswaran, S., Muir, J. and Chey, W.D., 2013. Fiber and functional gastrointestinal disorders. Official journal of the American College of Gastroenterology| ACG, 108(5), pp.718-727.

FIBER: microbiota mediated effects

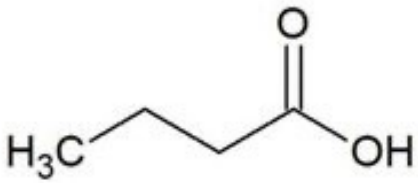
SCFA: Short chain fatty acids



Acetate ($C_2H_4O_2$)



Proprionate ($C_3H_6O_2$)



Butyrate ($C_4H_8O_2$)

"Production of short-chain fatty acids (SCFAs), especially butyrate, in the gut microbiome is required for optimal health but is frequently limited by the lack of fermentable fiber in the diet".

Baxter, N.T., Schmidt, A.W., Venkataraman, A., Kim, K.S., Waldron, C. and Schmidt, T.M., 2019. Dynamics of human gut microbiota and short-chain fatty acids in response to dietary interventions with three fermentable fibers. MBio, 10(1).

Effects attributed to increased microbial SCFA formation: GUT HEALTH

- improved gut barrier function
- reduced intestinal inflammation.
- butyrate is an [the] important fuel for the colonocytes.
- increased mucus production from epithelial goblet cells

- Blaak, E.E., Canfora, E.E., Theis, S., Frost, G., Groen, A.K., Mithieux, G., Nauta, A., Scott, K., Stahl, B., van Harsselaar, J. and van Tol, R., 2020. Short chain fatty acids in human gut and metabolic health. Beneficial microbes, 11(5), pp.411-455.

Effects attributed to increased microbial SCFA formation: SYSTEMIC HEALTH

- reduced incidence of obesity
- reduced T2 diabetes - via effects on body weight control, and energy intake and expenditure, added to the direct effect of reducing glucose absorption rate
- increased insulin sensitivity
- reduced systemic low-grade inflammation

Blaak, E.E., Canfora, E.E., Theis, S., Frost, G., Groen, A.K., Mithieux, G., Nauta, A., Scott, K., Stahl, B., van Harsselaar, J. and van Tol, R., 2020. Short chain fatty acids in human gut and metabolic health. Beneficial microbes, 11(5), pp.411-455.

Deehan, E.C. and Walter, J., 2016. The fiber gap and the disappearing gut microbiome: implications for human nutrition. Trends in Endocrinology & Metabolism, 27(5), pp.239-242.

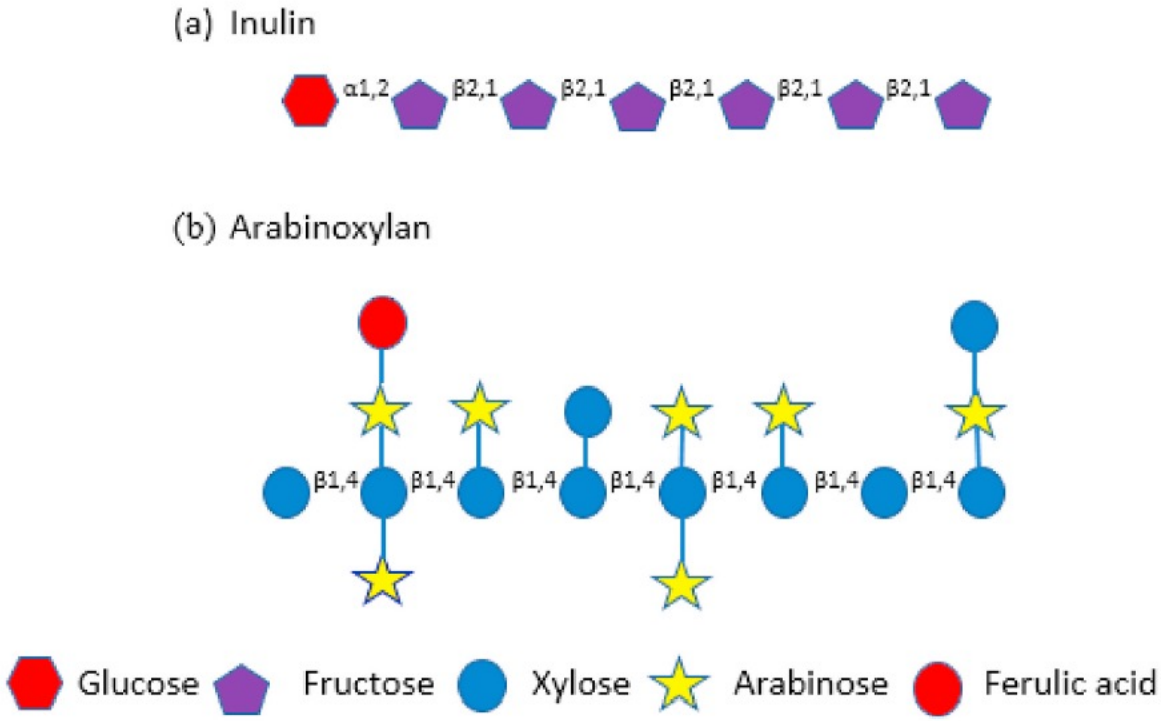
A Low-Fiber Diet is a Key Driver of Microbiome Depletion

"It is likely that a combination of factors (antibiotics, modern clinical practices, sanitation, dietary habits) have caused the decline in gut microbiome diversity.

…The only factor that has been empirically shown to be important [in reducing microbiome diversity] is a diet low in microbiota-accessible carbohydrates (MACs)".

Eat a diverse array of whole grains and pseudograins…

"The different assortments of enzymatic machineries in different microbial species results in specialization for fermenting specific fiber types".



Cantu-Jungles, T.M. and Hamaker, B.R., 2020. New view on dietary fiber selection for predictable shifts in gut microbiota. mBio 11: e02179-19.

Hamaker BR, Tuncil YE. 2014. A perspective on the complexity of dietary fiber structures and their potential effect on the gut microbiota. J Mol Biol 426:3838 –3850. https://doi.org/10.1016/j.jmb.2014.07.028.

Ayua, E.O., Kazem, A.E. and Hamaker, B.R., 2020. Whole grain cereal fibers and their support of the gut commensal Clostridia for health. Bioactive Carbohydrates and Dietary Fibre, 24, p.100245.

Ask not just what can you do for whole grains – but ask what can they do for you!

Cycling to work since 1998

As of Sept 20 2023 this bike: = 25,632 km
(nearly 16,000 miles) since Nov 23 2018

April 2018
2022: 51 years in the water

Sept 17 2023 – 53 years in the water - 66 years and 13 days

IG @wholegrainsurfer

Another element of my own experience with wholegrains and health –

Wow! – says my primary care physician. Updated with 2022 results

Patient Name: Andrew Ross | **Date of Birth:** 09/04/1957

LIPID PANEL 11/18/2020 (#14037175, Final, 11/18/2020 8:43am)

Note to Patient	Wow!			
Report	**Result**		**Ref. Range**	**Units**
HOURS FASTING	fasting			
CHOLESTEROL, TOTAL	155	153	50-199	mg/dl
	Testing performed on Ortho Diagnostics Vitros 5600 Analyzer.			
TRIGLYCERIDES	55	57	10-149	mg/dl
CHOLESTEROL/HDL RATIO	2.5 *	2.2	0.5-5.0	
LDL, CALCULATED	81	72	10-130	mg/dl
HDL	63	70	40-130	mg/dl

11/2022

LDL Cholesterol (mg/dL) - P

< 100	Optimal
100-129	Near optimal
130-159	Borderline high
>159	High

Total Cholesterol (mg/dL)

< 200	Desirable
200-239	Borderline high
>= 240	High

Serum Triglycerides (mg/dL)

< 150	Normal
150-199	Borderline high
>199	High

HDL Cholesterol (mg/dL)

< 40	Low
40-60	Desirable
> 60	Optimal

*Most healthcare providers want the ratio to be below 5:1.
A ratio below 3.5:1 is considered very good.
https://www.urmc.rochester.edu/encyclopedia

Ancient, ancestral, heritage and recent wheats

Emmer [left], einkorn [right]
Foto: Prof. Friedrich Longin
Universität Hohenheim

Gluten sensitivity and celiac disease:
Is gluten changing in “modern” versus “old” wheats

Gluten content

Pronin, D., Börner, A. and Scherf, K.A., 2021. Old and modern wheat (Triticum aestivum L.) cultivars and their potential to elicit celiac disease. Food Chemistry, 339, p.127952.

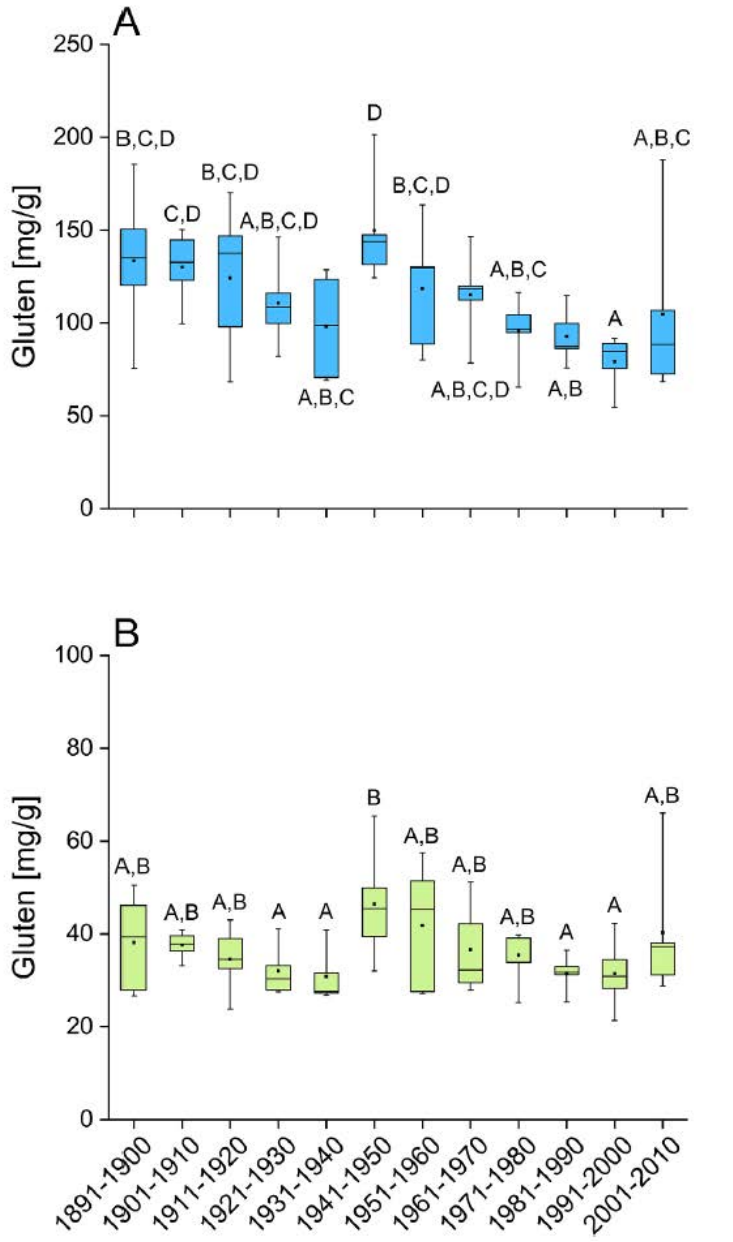


Fig. 3. Gluten contents determined by R5 (A) and G12 (B) ELISA test kits in five cultivars per decade as an average over three harvest years 2015–2017. Boxes represent the interquartile range with the median (line in the box) and mean (point in the box) and whiskers represent the minima and maxima. Different capital letters designate significant differences between the decades (one-way ANOVA, Tukey's test, $p < 0.05$).

Wheat…

Fernando et al. 2012 showed a 12.7% decrease in protein (~1% in absolute concentration) at 550 ppm* CO_2 and decreases in S, Ca, Fe, and Zn contents.

…reductions in nitrogen and minerals were not fully explained by biomass dilution.

Fernando, N., Panozzo, J., Tausz, M., Norton, R., Fitzgerald, G. and Seneweera, S., 2012. Rising atmospheric CO2 concentration affects mineral nutrient and protein concentration of wheat grain. Food Chemistry, 133(4), pp.1307-1311.

Fernando, N., Panozzo, J., Tausz, M., Norton, R. M., Neumann, N., Fitzgerald, G. J., Seneweera, S. 2014. Elevated CO2 alters grain quality of two bread wheat cultivars grown under different environmental conditions. Agriculture, Ecosystems and Environment, 185: 24–33.

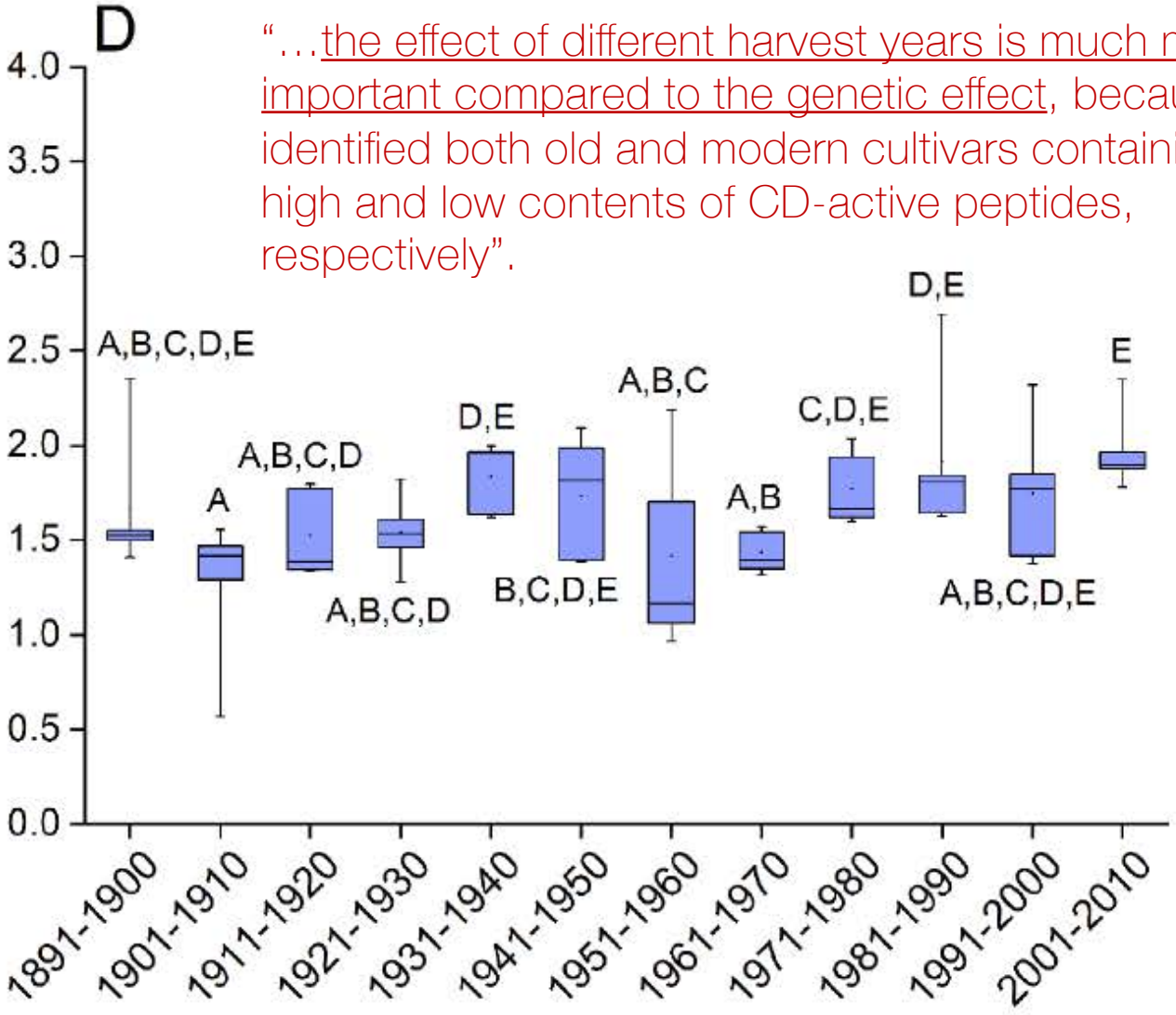
*around 2050 according to https://www.yaleclimateconnections.org/

Gluten sensitivity:
Is the gluten changing: “modern” versus “old” wheats

The alpha-gliadin 33-mer (p 56-88)

Pronin, D., Börner, A. and Scherf, K.A., 2021. Old and modern wheat (Triticum aestivum L.) cultivars and their potential to elicit celiac disease. Food Chemistry, 339, p.127952.

“…the effect of different harvest years is much more important compared to the genetic effect, because we identified both old and modern cultivars containing high and low contents of CD-active peptides, respectively”.



Proportions [%] of 33-mer based on α-gliadin contents in five cultivars per decade averaged over three harvest years 2015–2017 (D). Boxes represent the interquartile range with the median (line in the box) and mean (point in the box) and whiskers represent the minima and maxima. Different capital letters designate significant differences between the decades (one-way ANOVA, Tukey’s test, $p < 0.05$).

Brouns, F., Geisslitz, S., Guzman, C., Ikeda, T.M., Arzani, A., Latella, G., Simsek, S., Colomba, M., Gregorini, A., Zevallos, V. and Lullien-Pellerin, V., 2022. Do ancient wheats contain less gluten than modern bread wheat, in favour of better health?. Nutrition Bulletin.

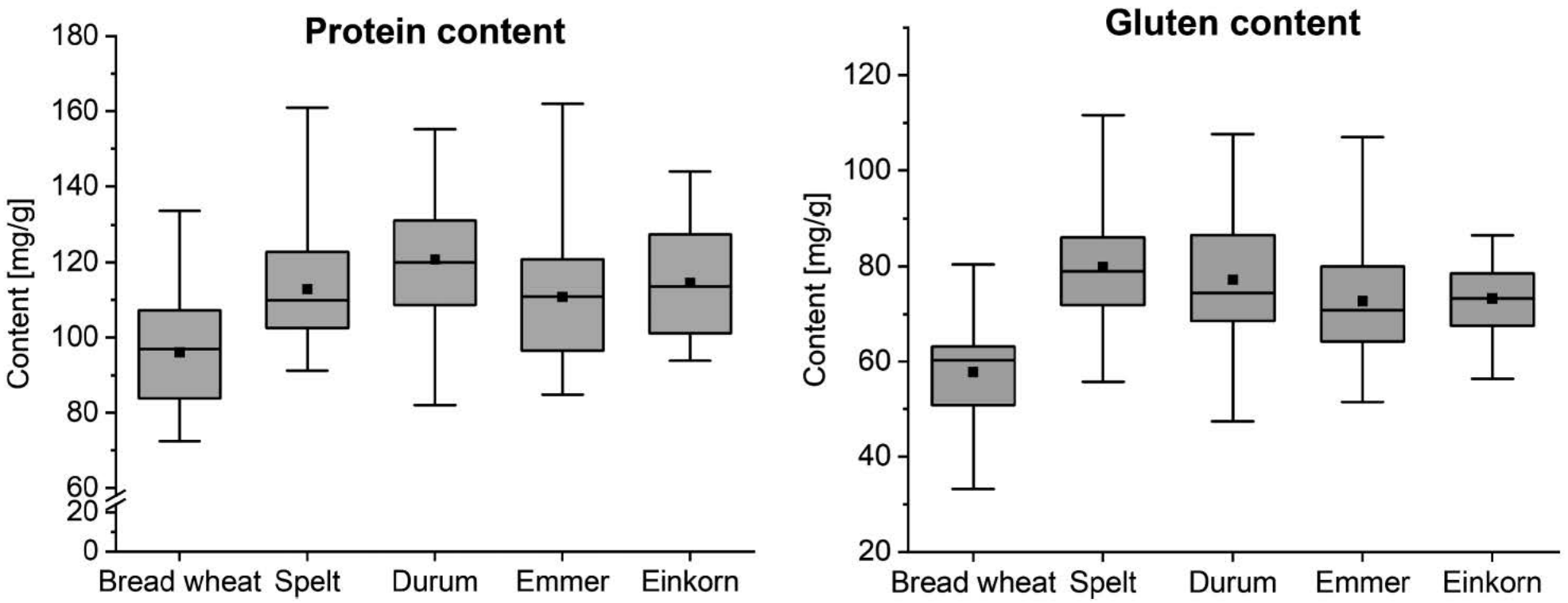
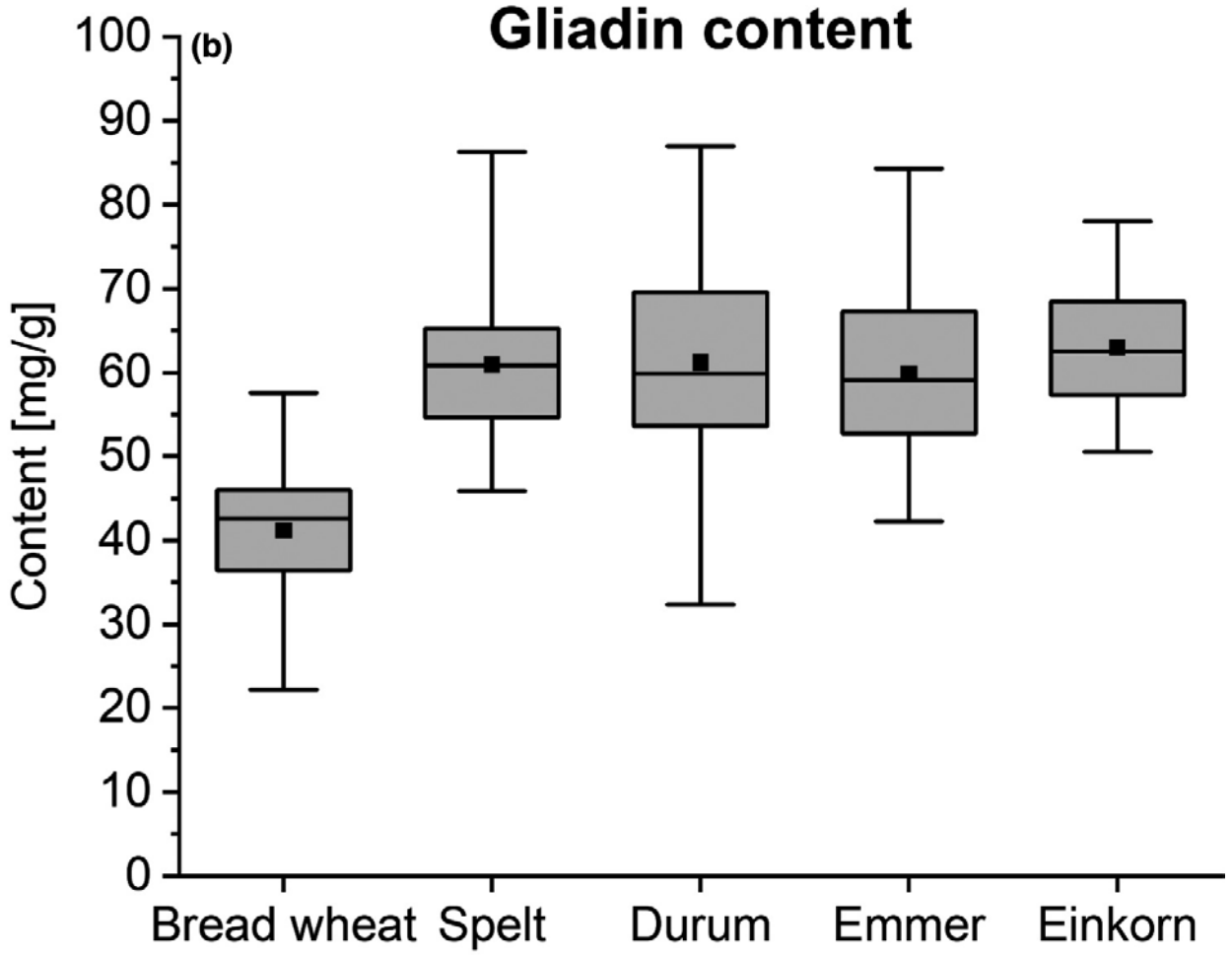


FIGURE 3 Ancient wheats contain more gluten. Total protein (left) and gluten content in bread wheat, spelt, durum wheat, emmer and einkorn (n = 15 cultivars grown at four locations (n = 60) in Germany). Modified with courtesy from Geisslitz et al. (2019)

Geisslitz, S., Longin, F.H.C., Scherf, A.K. & Koehler, P. (2019) Comparative study on gluten protein composition of ancient (einkorn, emmer and spelt) and modern wheat species (durum and common wheat). Foods, 8, 409.

Brouns, F., Geisslitz, S., Guzman, C., Ikeda, T.M., Arzani, A., Latella, G., Simsek, S., Colomba, M., Gregorini, A., Zevallos, V. and Lullien-Pellerin, V., 2022. Do ancient wheats contain less gluten than modern bread wheat, in favour of better health?. Nutrition Bulletin.



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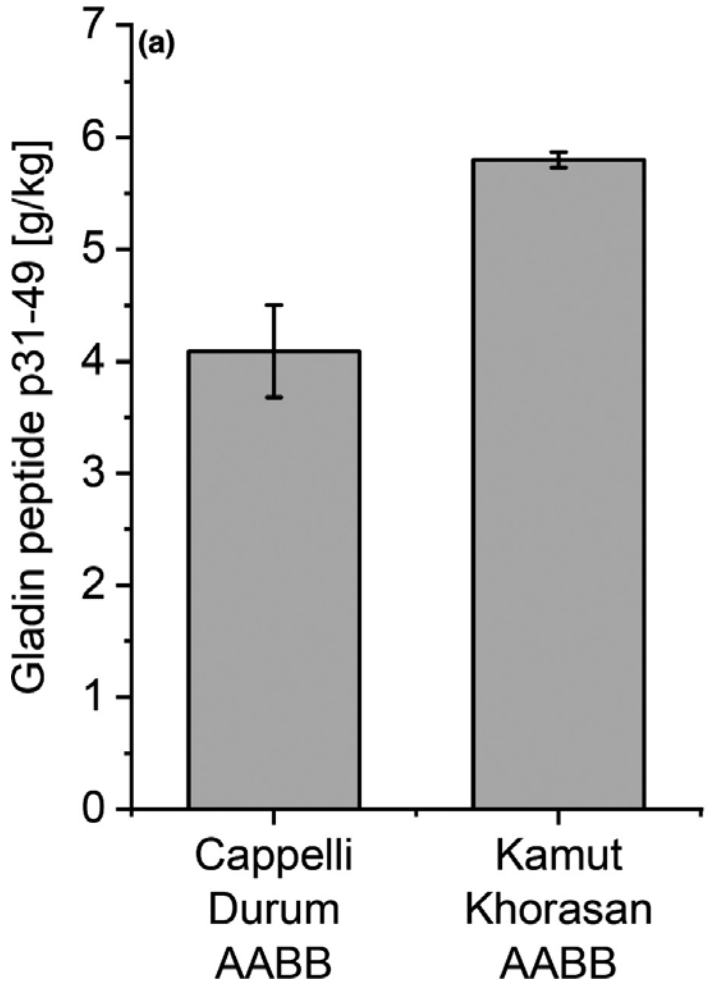
- "Example of a selected gliadin derived peptide (so-called p. 31–49), which was higher in 'ancient' wheat (Khorasan), compared to modern durum wheat (cultivar Cappelli). Figure kindly supplied by A. Gregorini, based on Gregorini et al. (2009)."



Gregorini, A., Colomba, M., Ellis, H.J. & Ciclitira, P.J. (2009). Immunogenicity characterization of two ancient wheat α-gliadin peptides related to coeliac disease. Nutrients, 1, 276–290.

Suter, D.A. and Békés, F., 2020. Who is to blame for the increasing prevalence of dietary sensitivity to wheat?. *Cereal Research Communications*, pp.1-19.

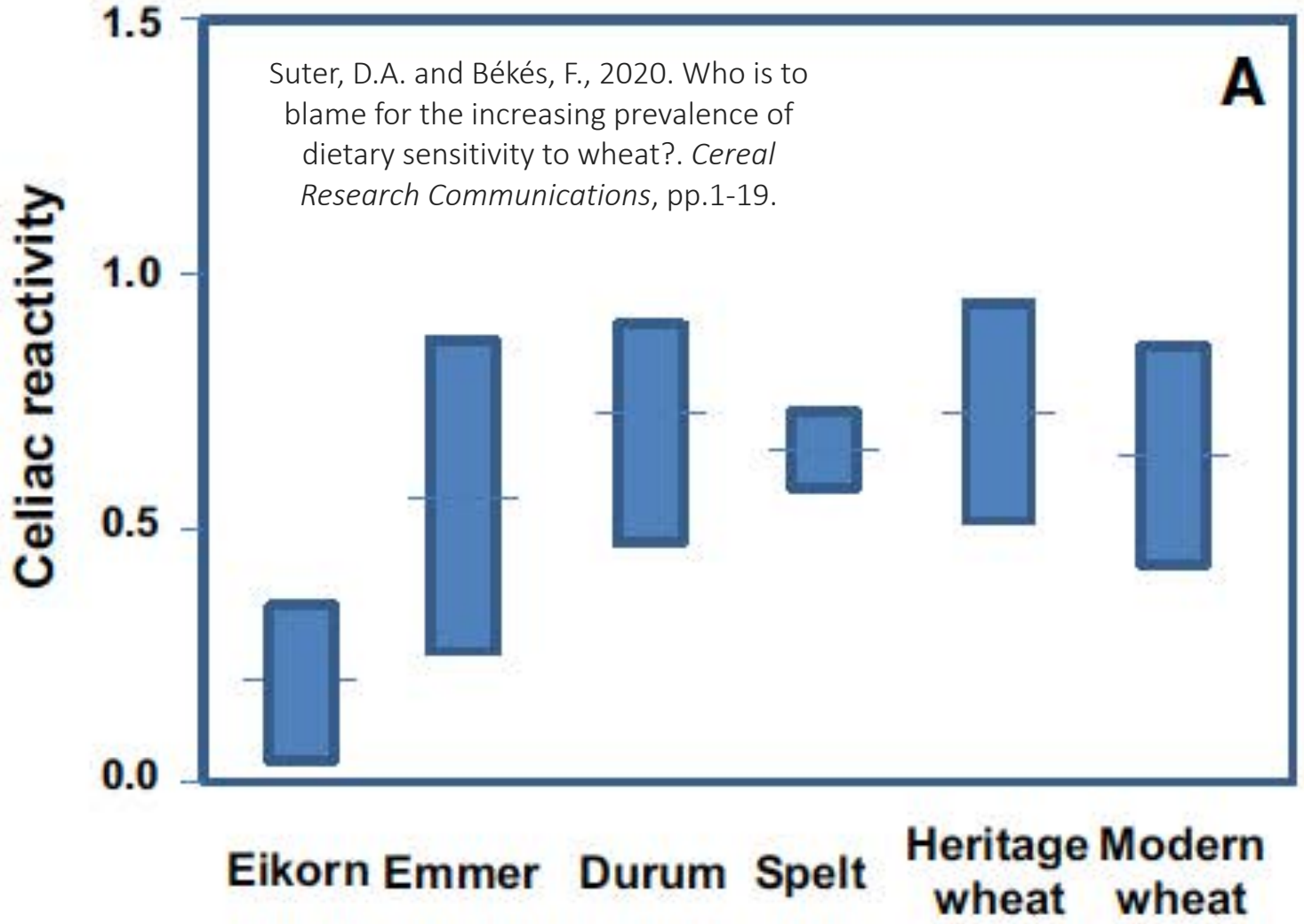


Fig. 1 Values reported in the literature within and among wheat types for **a** celiac reactivity, **b** human α-amylase inhibitor (ATI) activity, **c** allergenicity, and **d** fructan content. Horizontal lines indicate the median value for each of the value ranges. Modern wheat includes varieties of common wheat that were developed after 1950, while heritage wheat includes varieties and landraces that were developed before 1950

Einkorn

- "Our study shows that [einkorn] is toxic for CD patients as judged on histological and serological criteria, but it was well tolerated by the majority of patients,
- suggesting that [einkorn] is not safe for celiacs, but that it may be of value for patients with gluten sensitivity or for prevention of CD".

- Zanini, B., Villanacci, V., De Leo, L. *et al. Triticum monococcum* in patients with celiac disease: a phase II open study on safety of prolonged daily administration. *Eur J Nutr* **54,** 1027–1029 (2015). https://doi.org/10.1007/s00394-015-0892-3

- Dinu, M., Whittaker, A., Pagliai, G., Benedettelli, S. and Sofi, F., 2018. Ancient wheat species and human health: Biochemical and clinical implications. *The Journal of nutritional biochemistry*, *52*, pp.1-9.

- n: 7, m/f: 1/6, Age: 37±7.3 yrs.
- BMI: 22.8±3.1
- Celiac disease in remission for 1 yr. on GFD
- Total duration 60-day intervention trial
- Triticum monococcum (Einkorn) wheat (100 g/day) in the [form] of water biscuits

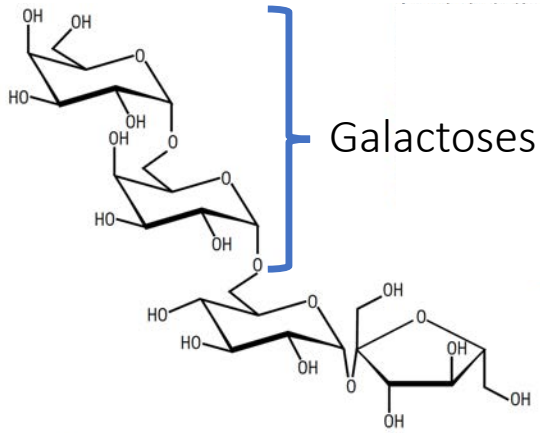
FODMAPs

- Fermentable oligo-, di-, and monosaccharides and polyols*

*e.g., sorbitol, xylitol

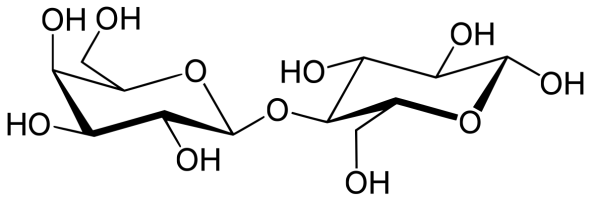
a fructo-oligosaccharide.

Ayua, E.O., Kazem, A.E. and Hamaker, B.R., 2020. Whole grain cereal fibers and their support of the gut commensal Clostridia for health. Bioactive Carbohydrates and Dietary Fibre, 24, p.100245.



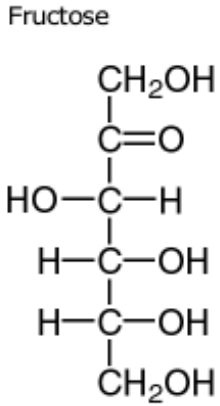
n = 2 – stachyose
n = 1 - raffinose

a galacto-oligosaccharide

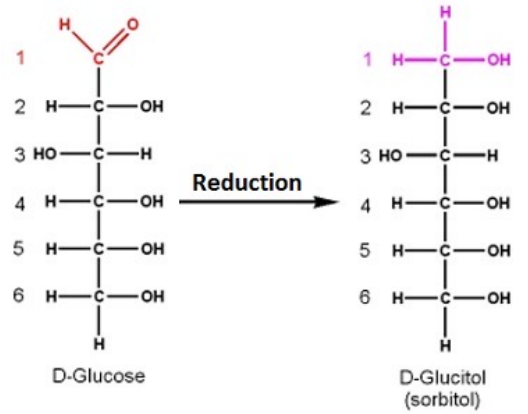


Lactose

disaccharide

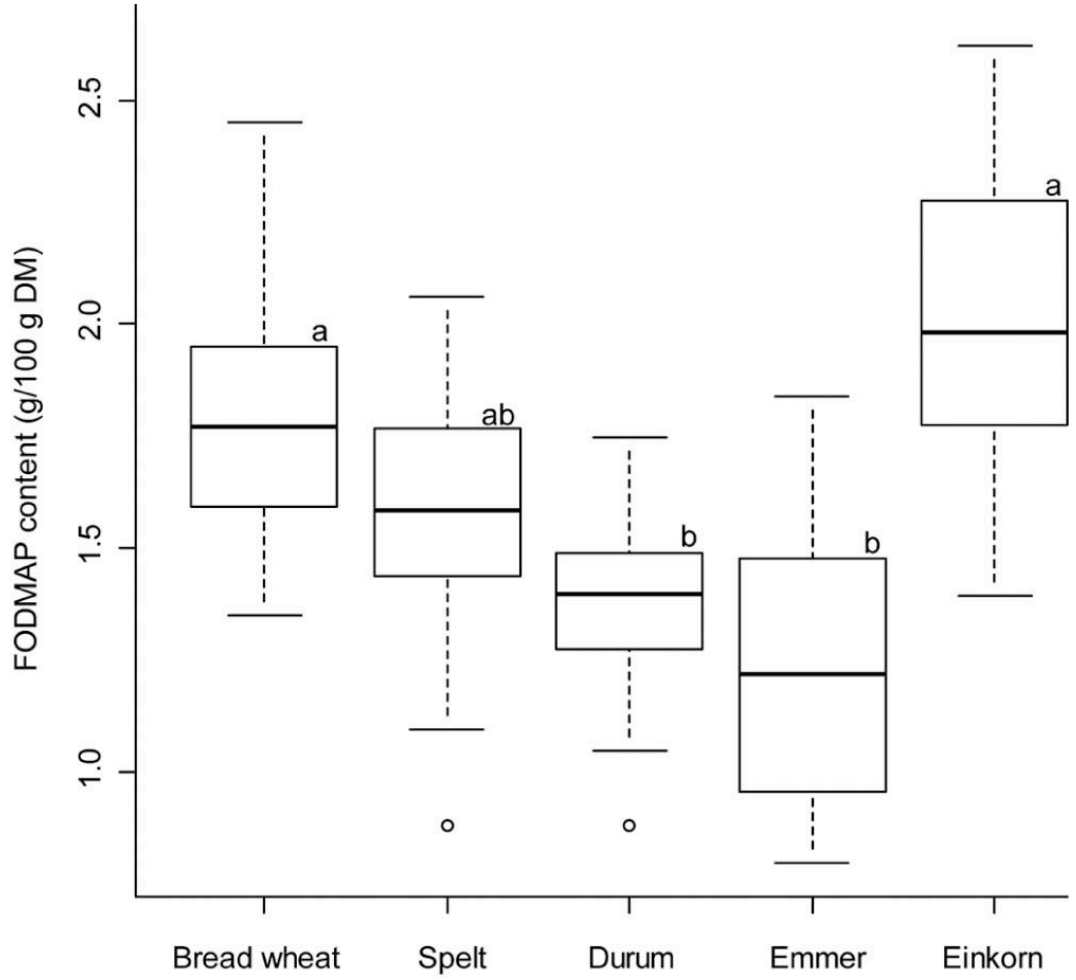


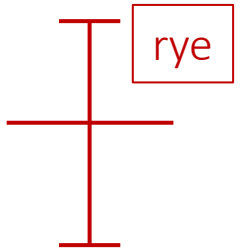
monosaccharide



polyol

FODMAPs and ancestral wheats





Schmidt, M., Sciurba, E. Determination of FODMAP contents of common wheat and rye breads and the effects of processing on the final contents. *Eur Food Res Technol* **247,** 395–410 (2021). https://doi.org/10.1007/s00217-020-03633-6

Fructans and fermentation

Mannitol

Fructans and raffinose

Ziegler JU, Steiner D, Longin CFH, Würschum T, Schweiggert RM, Carle R (2016) Wheat and the irritable bowel syndrome—FODMAP levels of modern and ancient species and their retention during bread making. J Funct Food 25:257–266. https ://doi.org/10.1016/j.jff.2016.05.019

“Digestibility” and fermentation

- Enhanced protein digestibility ?
- Retarded starch digestibility

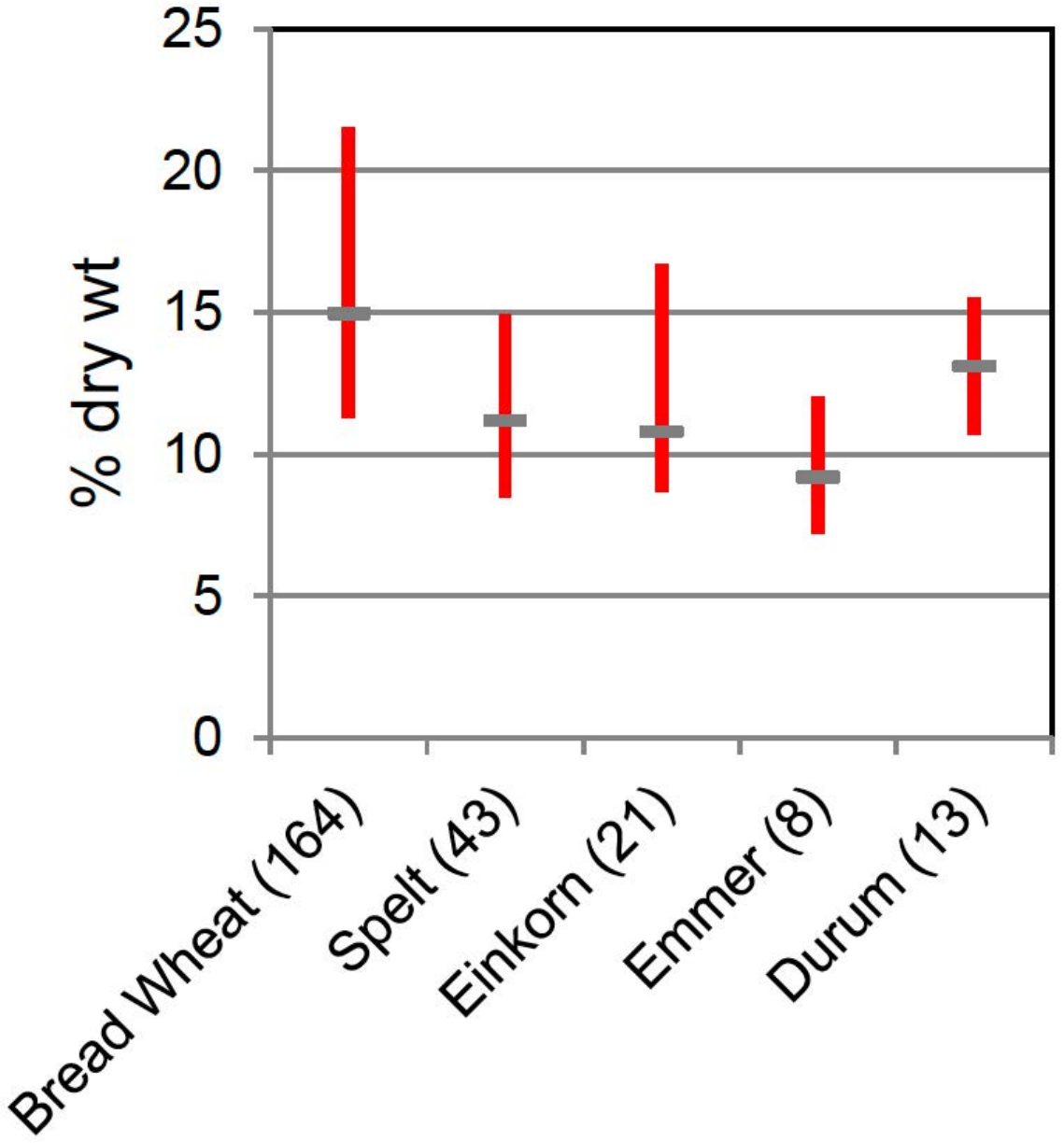
Are ancestral wheats (and rye and barley) enriched in specific nutritional components vs recent hexaploid wheats?

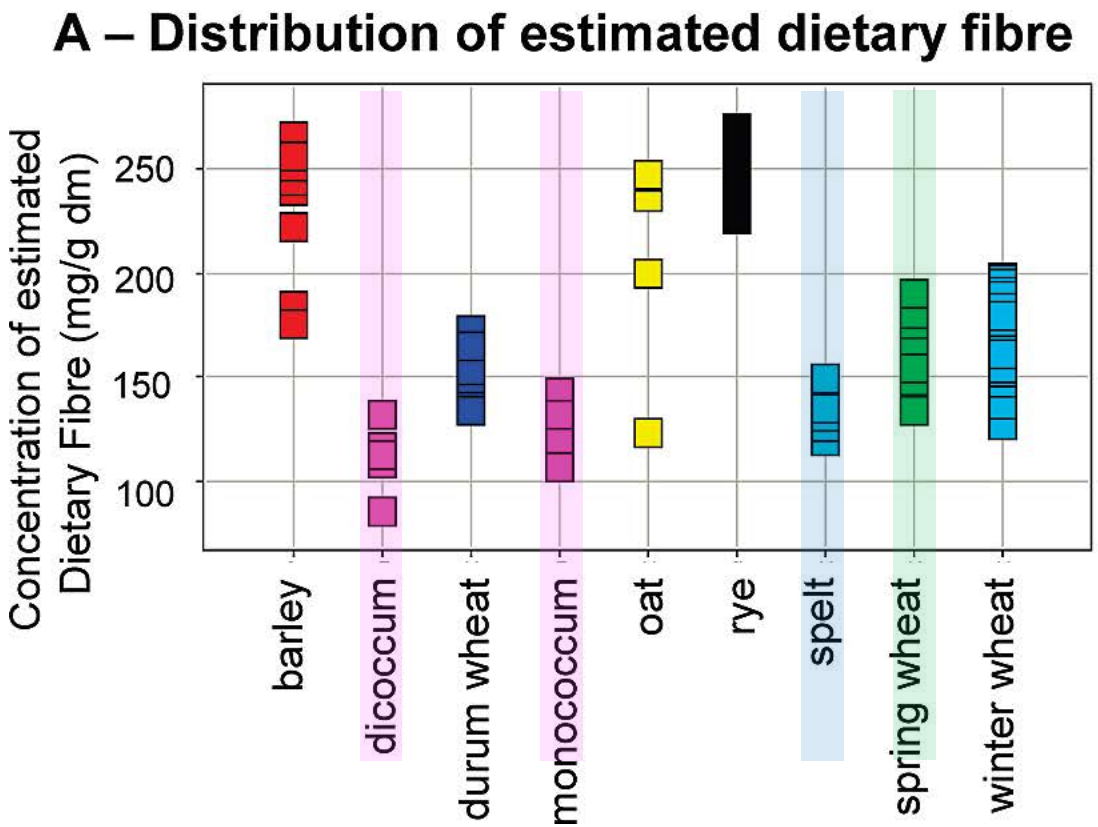
TDF

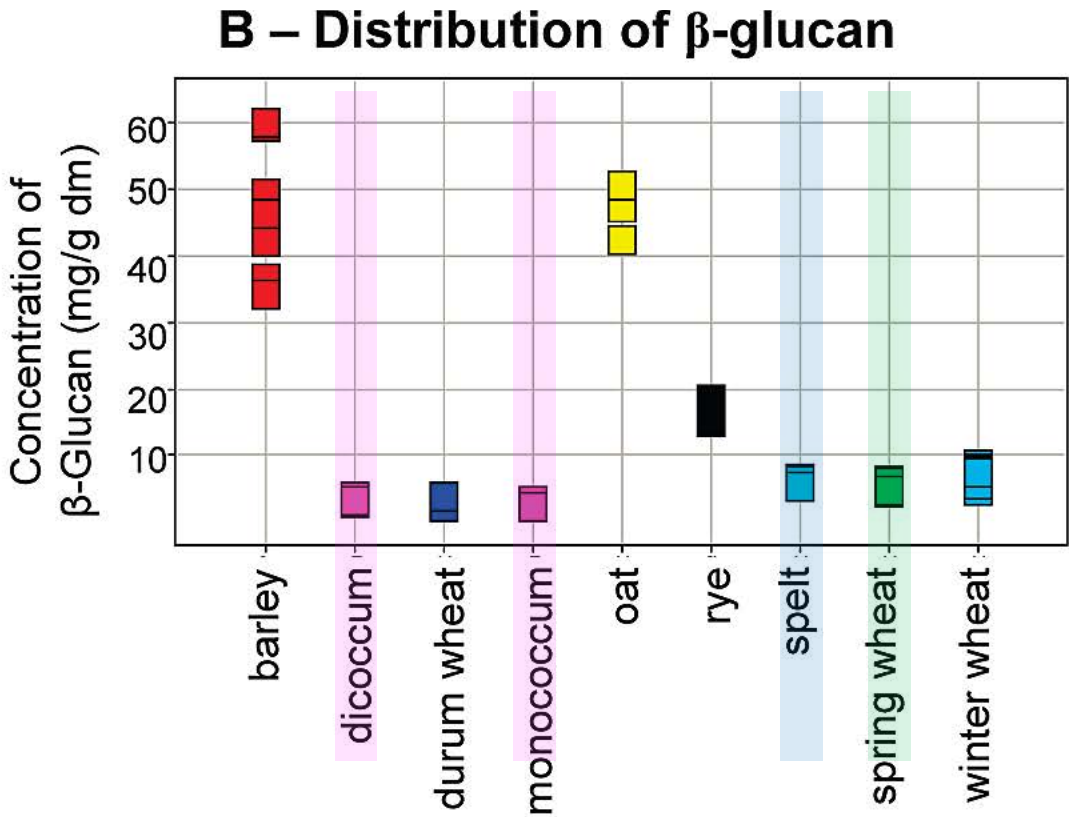
- Reported contents of total dietary fiber in ancient and modern wheat species.

- Shewry, P.R. and Hey, S., 2015. Do “ancient” wheat species differ from modern bread wheat in their contents of bioactive components?. *Journal of Cereal Science*, *65*, pp.236-243.

- Lower levels of TDF in emmer are disputed with evidence, in the review by Čurná, V. and Lacko-Bartošová, M., 2017. Chemical composition and nutritional value of emmer wheat (Triticum dicoccon schrank): A review. *Journal of Central European Agriculture*.

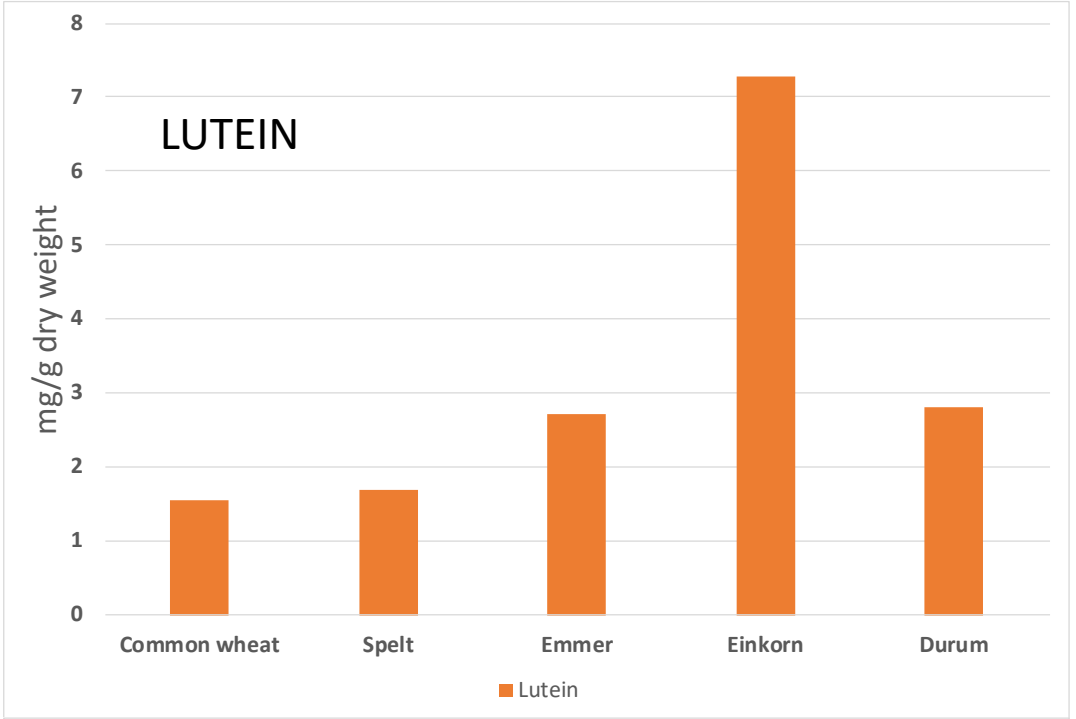


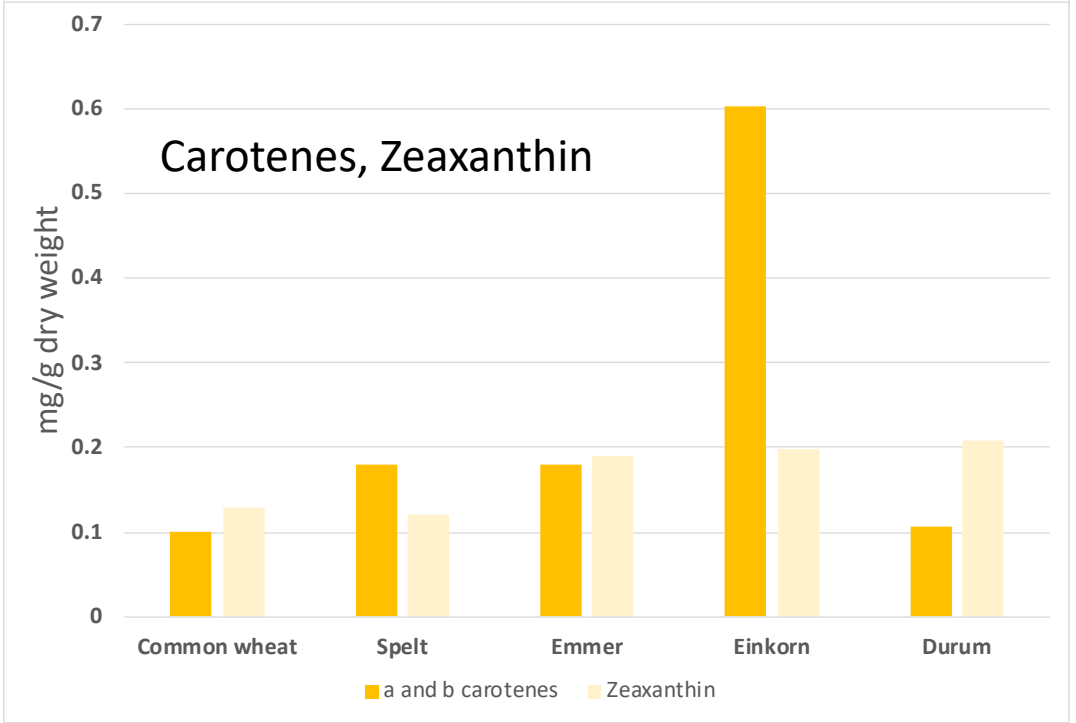


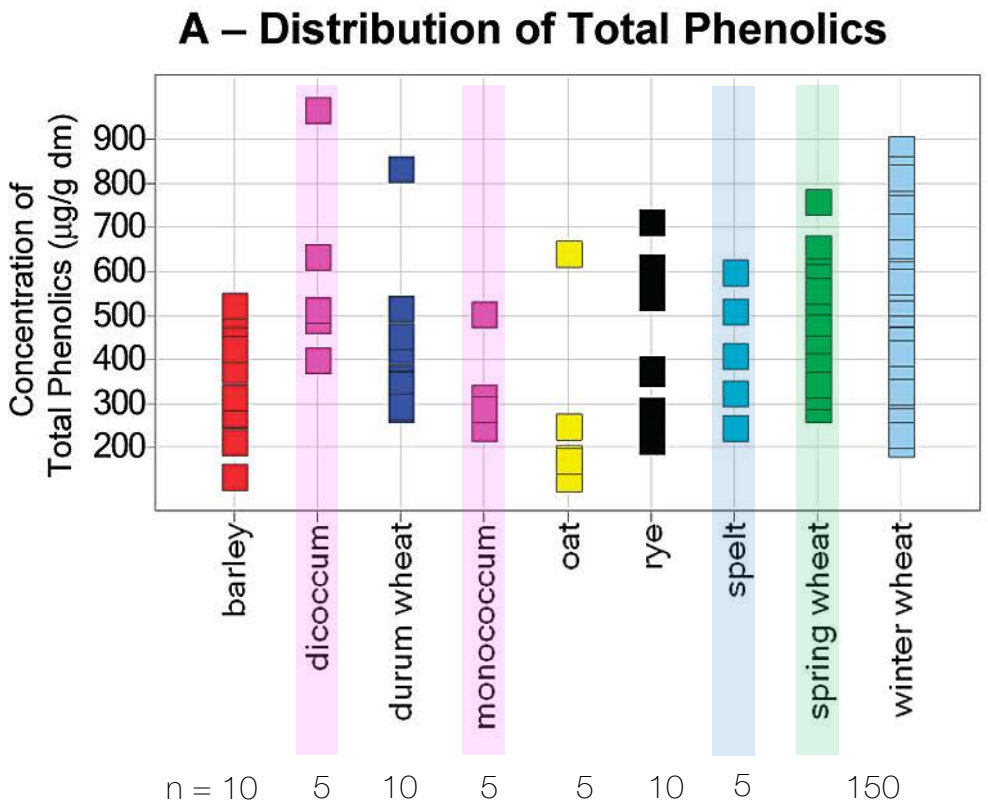


Ward, J.L., Poutanen, K., Gebruers, K., Piironen, V., Lampi, A.M., Nyström, L., Andersson, A.A., Boros, D., Rakszegi, M., Bedő, Z. and Shewry, P.R., 2008. The HEALTHGRAIN cereal diversity screen: concept, results, and prospects. Journal of Agricultural and Food Chemistry, 56(21), pp.9699-9709.

Adapted from Table 3 - Shewry, P.R. and Hey, S., 2015. Do “ancient” wheat species differ from modern bread wheat in their contents of bioactive components?. *Journal of Cereal Science*, *65*, pp.236-243.







Ward, J.L., Poutanen, K., Gebruers, K., Piironen, V., Lampi, A.M., Nyström, L., Andersson, A.A., Boros, D., Rakszegi, M., Bedő, Z. and Shewry, P.R., 2008. The HEALTHGRAIN cereal diversity screen: concept, results, and prospects. Journal of Agricultural and Food Chemistry, 56(21), pp.9699-9709.

Minerals in general

- “10 emmer and ten spelt accessions vs 2 common wheats and 3 durums, 1 location.

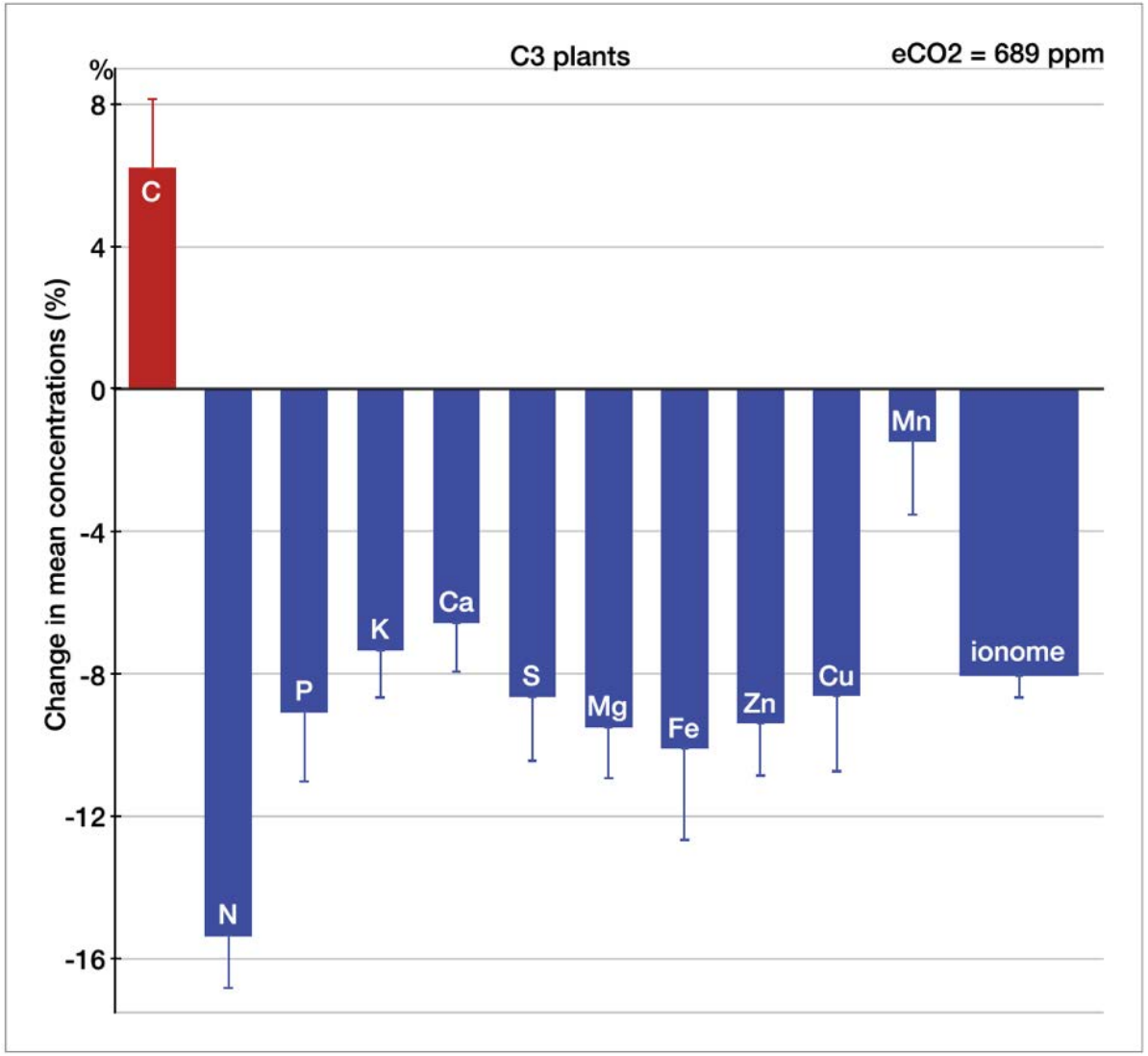
- Emmer and spelt wheat differed from common and durum wheat cultivars in having higher levels of lithium, magnesium, phosphorus, selenium, and zinc.

- The highest levels for all minerals tested were found in spelt accessions.

- Ash content in emmer was usually higher (>2.0% db) than in durum and common wheat (1.7 – 1.8% db).

- The low ash content of modern wheat cultivars is the result of selection…”.

- Čurná, V. and Lacko-Bartošová, M., 2017. Chemical composition and nutritional value of emmer wheat (Triticum dicoccon schrank): A review. *Journal of Central European Agriculture*.



Loladze, I., 2014. Hidden shift of the ionome of plants exposed to elevated CO_2 depletes minerals at the base of human nutrition. *Elife*, *3*, p.e02245.

The effect of CO_2 on individual chemical elements in plants. Change (%) in the mean concentration of chemical elements in plants grown in elevated CO_2 relative to those grown at ambient levels. C3 plants. Average ambient and elevated CO_2 levels are 368 ppm and 689* ppm respectively.

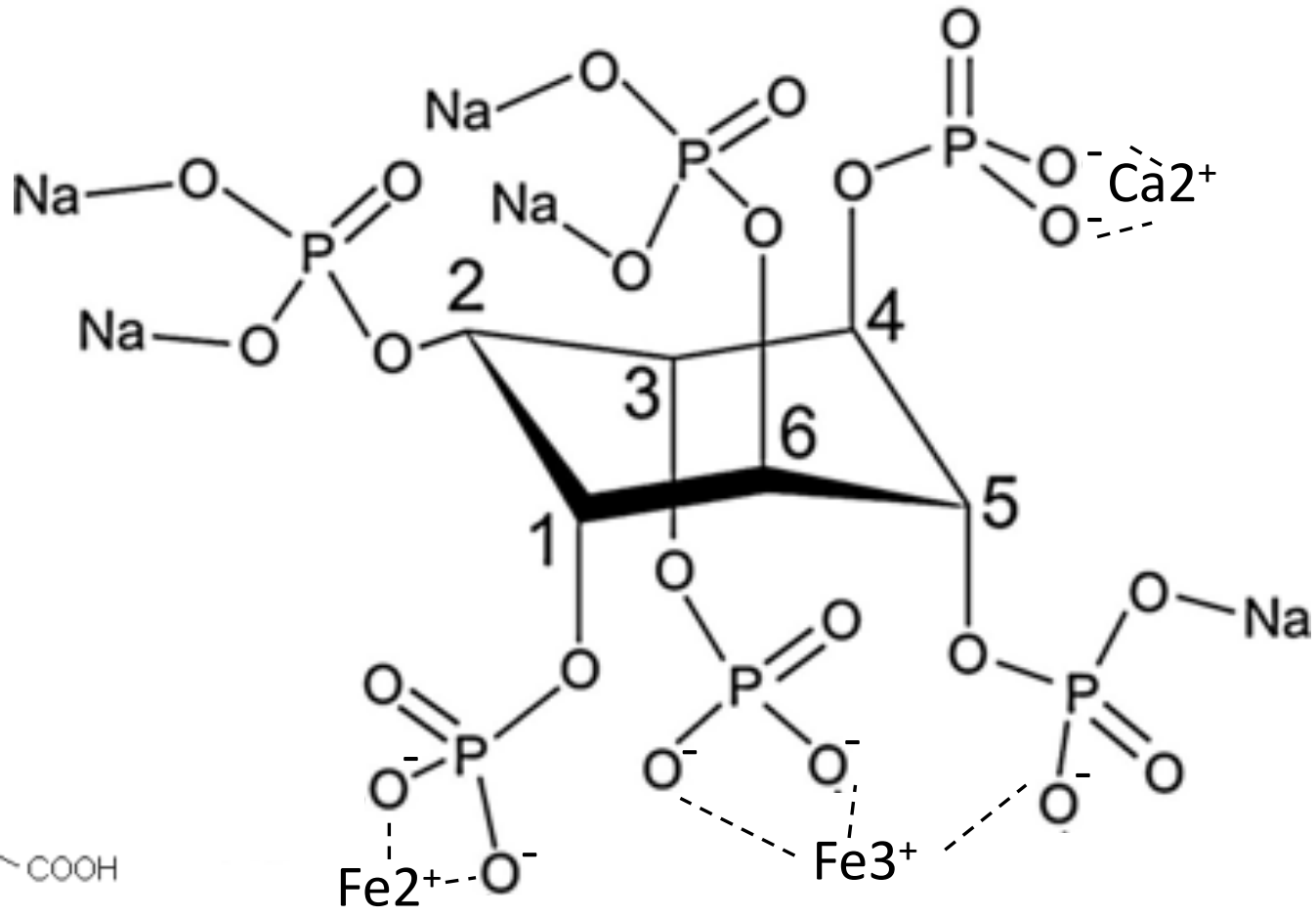
The results reflect plant data (foliar and edible tissues, FACE and non-FACE studies) from four continents.

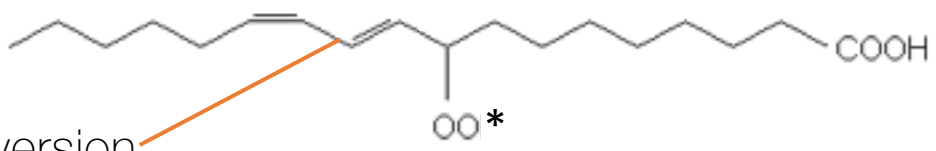
Zhu, C., Kobayashi, K., Loladze, I., Zhu, J., Jiang, Q., Xu, X., Liu, G., Seneweera, S., Ebi, K.L., Drewnowski, A. and Fukagawa, N.K., 2018. Carbon dioxide (CO2) levels this century will alter the protein, micronutrients, and vitamin content of rice grains with potential health consequences for the poorest rice-dependent countries. Science Advances, 4(5), p.eaaq1012.

*2070 to 2075 according to https://www.yaleclimateconnections.org/

Fe^{2+} Zn^{2+}

Phytic acid/phytate, fermentation, mineral availability





Cis to trans conversion

A linoleic acid peroxyl-radical

Some things I have not addressed…

- Genetic diversity
- Deep roots and soil health
- Climate resilience
- Dietary diversity
- Peas, beans, lentils

- Fun…

100% wholegrain
spelt sourdough
bread

flour
water
salt
microbes