Amidon, fibres alimentaires et qualité nutritionnelle du blé

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INRA - UR 1268 Biopolymères Interactions Assemblages (BIA)

Nantes – FRANCE

- *Etat de l'art sur la question des fibres alimentaires*
- *Part de la technologie dans les effets nutritionnels*
- *Potentialités de la sélection pour moduler les polymères glucidiques à des fins nutritionnelles*
- *Tendances des recherches en nutrition autour des fibres / amidon*

Plan de l'exposé

- Données épidémiologiques et définitions des fibres alimentaires
- Mécanismes d'action et effet santé des fibres
- Origine et spécificité des fibres des grains de céréales
- Effets des différentes fibres de céréales et leur variabilité
- Amidon résistant (et index glycémique)
- Le concept « whole grain »
- Conclusions

Epidémiologie: un peu d'histoire …

1408 THE LANCET, DECEMBER 30, 1972

Occasional Survey

EFFECT OF DIETARY FIBRE ON STOOLS AND TRANSIT-TIMES, AND ITS ROLE IN THE CAUSATION OF DISEASE

D. P. BURKITT
Medical Research Council External Scientific Staff, London W.1

A. R. P.
M.R.C. Human Bioche
South African Institute
Johannesburg,

N. S. P

American Journal of Epidemiology

Vol. 181, No. 2
DOI: 10.1093/aje/kwu257
Advance Access publication: December 31, 2014

Systematic Reviews and Meta- and Pooled Analyses

Association Between Dietary Fiber and Lower Risk of All-Cause Mortality: A Meta-Analysis of Cohort Studies

Yang Yang, Long-Gang Zhao, Qi-Jun Wu, Xiao Ma, and Yong-Bing Xiang*

* Correspondence to Prof. Y.-B. Xiang, Shanghai Cancer Institute, Renji Hospital, Shanghai Jiaotong University School of Medicine, No. 25, Lane 2200, Xie Tu Road, Shanghai 200032, People's Republic of China (e-mail: ybxiang@shsci.org).

Définition des fibres alimentaires

- **2008/100/EC**

  - **Polymères de glucides (DP>3), qui ne sont ni digérés ni absorbés au niveau de l'intestin grêle de l'homme appartenant aux catégories suivantes:**

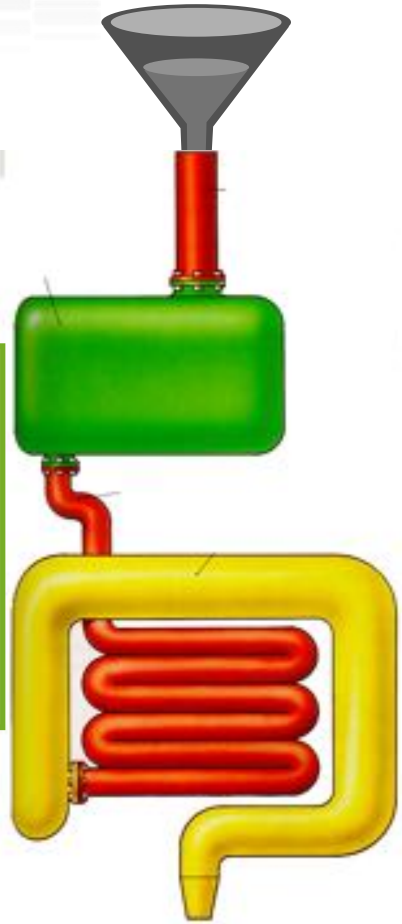
- présents naturellement dans les aliments (+lignines et composés associés)
- extraits des végétaux et avec des effets bénéfiques scientifiquement démontrés
- synthétiques avec des effets bénéfiques scientifiquement démontrés

Les mécanismes d'action des fibres

Effets sur la structure de la matrice alimentaire

Fibres Solubles:
viscosité

Fibres insolubles :
Capacité de rétention d'eau
Taille de particules



Kaisa Poutanen

Bouche
Mastication

Estomac
Vidange gastrique

Intestin grêle
Digestion-absorption des macronutriments

Colon
Fermentation
↕
Microbiote

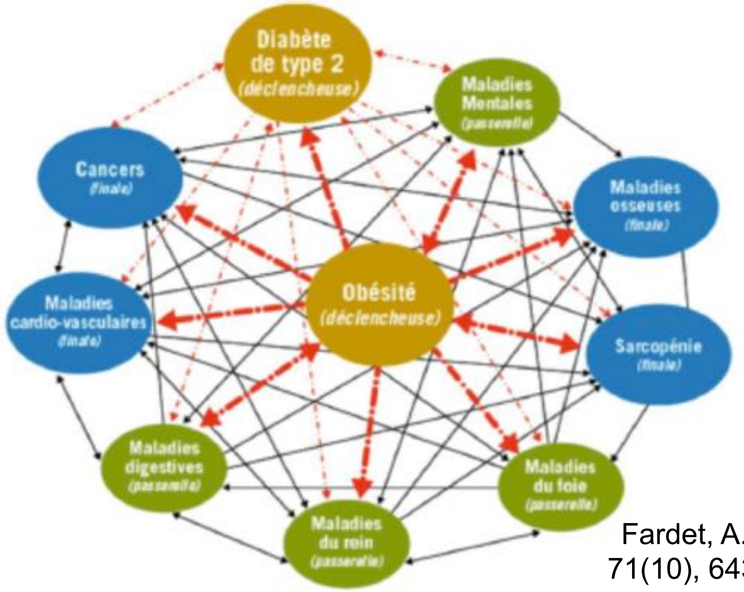
Métabolisme
du glucose et des lipides

Obésité
Diabète NIDDM
Maladie cardiovasculaire

Transit Intestinal
AGCC
Effet prébiotique

Santé du colon
cancer, maladie inflammatoire
…

Associations entre maladies chroniques liées à l'alimentation



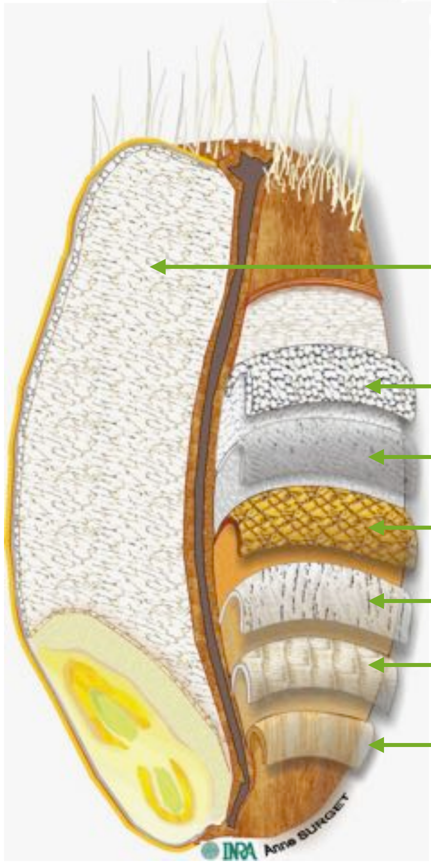
Fardet, A., & Boirie, Y. (2013). Nutrition Reviews, 71(10), 643–656. http://doi.org/10.1111/nure.12052

➢ Recommandations nutritionnelles

- **Augmenter la consommation de fibres dans notre régime alimentaire -> 25g-35g/jour - En France consommation « moyenne » ~17g/jour**

Les fibres alimentaires dans le blé

➢ **Teneur: 12-18% p/p (grain entier)**



Albumen amylacé
(80-83 % du grain)
~ 25% des fibres
Amidon & protéines

Couche à aleurone
(6-7 % du grain)
~ 25% des fibres
P, Mg, Mn, Fe
Vitamines, choline, bétaïne
Lignanes

Enveloppes externes
(6-8 % du grain)
~ 50% des fibres
Alkylresorcinols

Nature des parois

ArabinoXylanes (AX)
Beta-Glucanes (MLG)
AX & MLG partiellement hydrosoluble
+ *Cellulose*

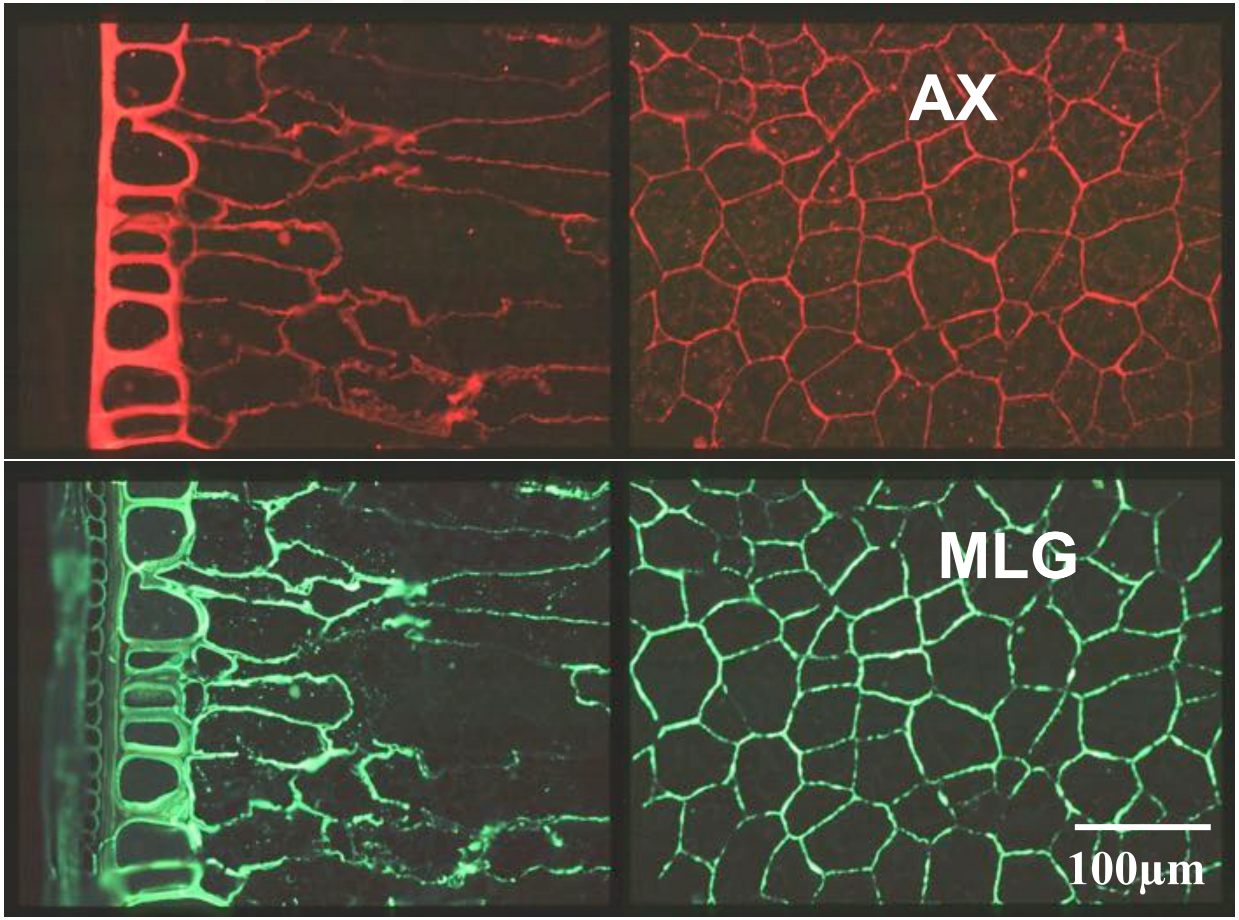
≠

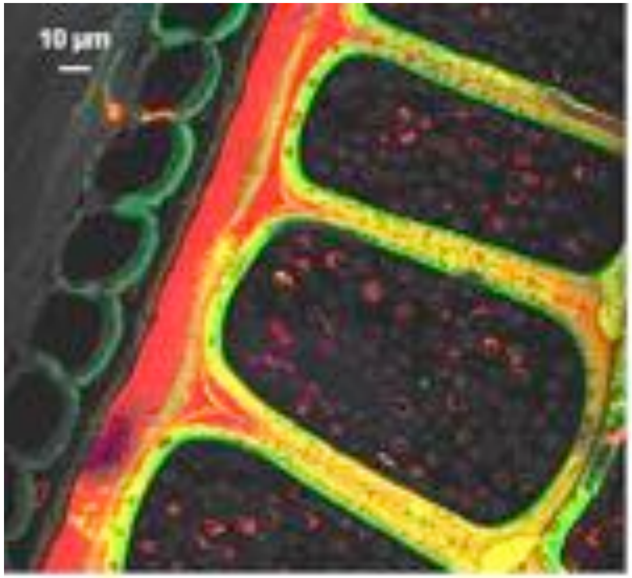
Xylanes
Cellulose
+ *Lignines*

\+

Fructanes
~2 % du grain

AX and MLG in endosperm cell walls





Immunolabelling of cell walls polysaccharides

MLG in green and AX in orange

Dietary fibre content in cereal grains

Mean value *Min-max*	**Bread wheat**	**Durum wheat**	**Spelt wheat**	**Einkorn wheat**	**Rye**	**Barley « hulled »**	**Barley « naked »**	**Oat**
TDF (g/100g grain)	**15,2** *11,5-18,3*	**13,4** *10,7-15,5*	**12,0** *10,7-13,9*	**11,0** *9,3-12,8*	**22,6** *20,4-25,2*	**22,4** *20-23,8*	**15,2** *15-15,4*	**21,8** *18.5-23.4*
MLG (g/100grain)	**0,75** *0,50-0,95*	**0,35** *0,25-0,45*	**0,65** *0,55-0,70*	**0,3** *0,25-0,35*	**1,8** *1,7-2,0*	**4,9** *4.0-6.4*	**5,6** *4,6-6.5*	**5,1** *4.5-5.6*
Lignin (g/100g grain)	**2,2** *1,40-3,25*	**2,1** *1,85-2,55*	**2,2** *1,85-2,90*	**2,6** *2,25-3,05*	**2,4** *2,0-2,9*	**4,2** *3,9-4,7*	**3,6** *3,3-3.8*	**4,8** *4.2-5.9*
AX Flour (g/100g farine)	**1,9** *1,35-2,75*	**1,95** *1,70-2,35*	**1,75** *1,60-2,15*	**1,95** *1,45-2,35*	**3,64** *3,11-4,31*	**2,0** *1.5-2.2*	**1,71** *1,4-2.0*	**1,15** *1.05-1.26*
AX Bran (g/100g sons)	**18** *13,2-22,1*	**12** *10,9-13,7*	**12,7** *11,1-13,9*	**10** *9,5-10,4*	**13,3** *12,1-14,8*	**8,1** *5.8-9.9*	**5,4** *6,0-4.8*	**10,4** *8.0-13.2*

Gebruers, K., et al. (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(21), 9740.

Andersson, A. A. M. et al. (2008). Phytochemical and Dietary Fiber Components in Barley Varieties in the HEALTHGRAIN Diversity Screen. Journal of Agricultural and Food Chemistry, 56(21), 9767

Nyström, L.et al.. (2008). Phytochemicals and Dietary Fiber Components in Rye Varieties in the HEALTHGRAIN Diversity Screen. Journal of Agricultural and Food Chemistry, 56(21), 9758.

Shewry, P. R.et al. (2008). Phytochemical and Fiber Components in Oat Varieties in the HEALTHGRAIN Diversity Screen. Journal of Agricultural and Food Chemistry, 56(21), 9777.

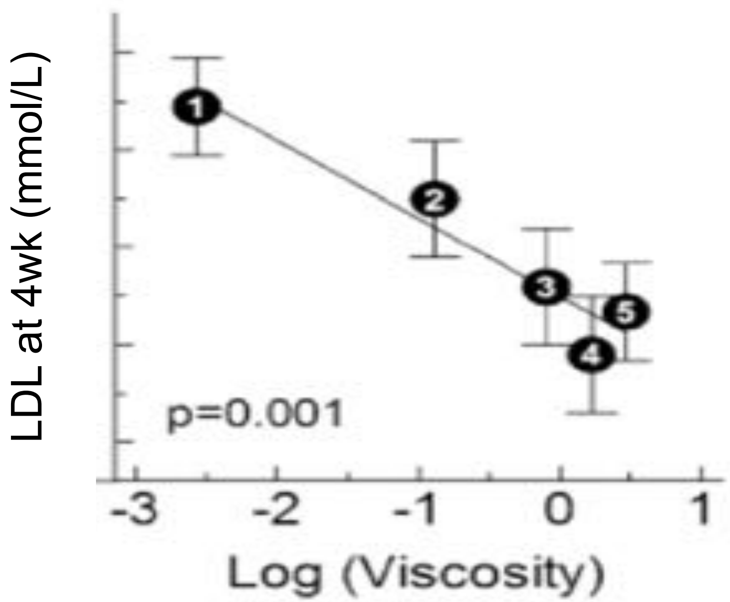
Effect of oat MLG on cholesterol level

Wolever, T. M et al. (2010) *Am J Clin Nutr 92*, 723-732.

EFSA Claim
« oat beta-glucan can actively lower/ reduce blood LDL and total cholesterol »

doses at least 3 g/d

EFSA Journal 2010;8(12):1885



1 Wheat bran cereal
2 4g MLG **low Mw**
3 3g MLG medium Mw
4 4g MLG medium Mw
5 3g MLG **high Mw**

Viscosity = *f* (concentration) & *f* (hydrodynamic volume)

FIGURE 4. Relations between log(MW × C) and serum LDL cholesterol, log(viscosity) and serum LDL cholesterol, and log(MW × C) and log(viscosity). Values are means ± SEMs for the 5 treatments: 1 = wheat-bran cereal (*n* = 87), 2 = 4 g low-MW; *β*-glucan (*n* = 63), 3 = 3 g medium-MW *β*-glucan (*n* = 64), 4 = 4 g medium-MW *β*-glucan (*n* = 67), 5 = 3 g high-MW *β*-glucan (*n* = 86). Solid lines are regression equations. *P* values for the correlations with LDL cholesterol are from the ANCOVA. No regression line or *P* value for log(MW × C) and log(viscosity) is shown because the relation is not linear across the observed range of viscosity (44). MW, molecular weight; C, amount of oat *β*-glucan solubilized in the intestine.

Effet des hypoglycémiants des AX d'albumen

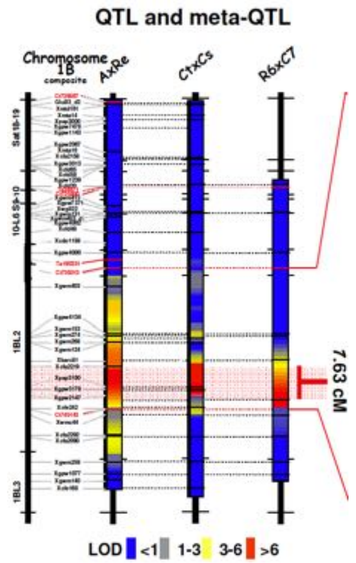
➢ Health claims related to arabinoxylan produced from wheat endosperm and reduction of post-prandial glycaemic responses. EFSA Journal (2011) 9, 15: **8g/j**

White flour 150 cultivars Healthgrain	WE-AX (g/100g)	AX-Total (g/100g)
Mean	0,51	1,93
Max	1,38	2,74
Min	0,29	1,36
CV %	27	13

Gebruers, K.et al.. (2008). Journal of Agricultural and Food Chemistry **56,** 9740.

HEALTHGRAIN

Meta-QTL 1B, 3D, 6B



Masood Quraishi, U. et al. (2010) *Functional & Integrative Genomics 11*, 71-83.

Allégations nutritionnelles reconnues par l'EFSA pour les fibres de céréales

Beta-Glucanes d'avoine : effet hypocholestérolémiant (3 g/ jour)
Scientific Opinion on the substantiation of a health claim related to oat beta glucan and lowering blood cholesterol and reduced risk of (coronary) heart disease. EFSA Journal (2010) 8, 15.

ArabinoXylanes de Blé : effet hypoglycémiant (8g/ jour)
Scientific opinion on the substantiation of health claims related to arabinoxylan produced from wheat endosperm and reduction of post-prandial glycaemic responses. EFSA Journal (2011) 9, 15

Sons de Blé : reduction du temps de transit intestinal (10g/ jour)
Scientific opinion on the substantiation of health claims related to wheat bran fibre reduction in intestinal transit time. EFSA Journal (2010) 8, 1817

Available online at www.sciencedirect.com

ScienceDirect

Current Opinion in Microbiology

ELSEVIER

Microbiome, metabolites and host immunity

Maayan Levy[1], Eran Blacher[1] and Eran Elinav

CrossMark

REVIEW

Diet–microbiota interactions as moderators of human metabolism

Justin L. Sonnenburg[1] & Fredrik Bäckhed[2,3]

It is widely accepted that obesity and associated metabolic diseases, including type 2 diabetes, are intimately linked to diet. However, the gut microbiota has also become a focus for research at the intersection of diet and metabolic health. Mechanisms that link the gut microbiota with obesity are coming to light through a powerful combination of translation-focused animal models and studies in humans. A body of knowledge is accumulating that points to the gut microbiota as a mediator of dietary impact on the host metabolic status. Efforts are focusing on the establishment of causal relationships in people and the prospect of therapeutic interventions such as personalized nutrition.

Neurobiology of Stress 7 (2017) 124–136

Contents lists available at ScienceDirect

Neurobiology of Stress

journal homepage: http://www.journals.elsevier.com/neurobiology-of-stress/

ELSEVIER

Stress & the gut-brain axis: Regulation by the microbiome

CrossMark

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[c] APC Microbiome Institute, University College Cork, Cork, Ireland
[d] Department of Anatomy and Neuroscience, University College Cork, Cork, Ireland

Article

Cell

A Dietary Fiber-Deprived Gut Microbiota Degrades the Colonic Mucus Barrier and Enhances Pathogen Susceptibility

Mahesh S. Desai,[1,2,3,7,*] Anna M. Seekatz,[2] Nicole M. Koropatkin,[2] Nobuhiko Kamada,[2] Christina A. Hickey,[4] Mathis Wolter,[1] Nicholas A. Pudlo,[2] Sho Kitamoto,[2] Nicolas Terrapon,[5] Arnaud Muller,[6] Vincent B. Young,[2] Bernard Henrissat,[5] Paul Wilmes,[1] Thaddeus S. Stappenbeck,[4] Gabriel Núñez,[2] and Eric C. Martens[2,8,*]

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[8] Lead Contact
*Correspondence: mahesh.desai@lih.lu (M.S.D.), emartens@umich.edu (E.C.M.)

http://dx.doi.org/10.1016/j.cell.2016.10.043

Review

A Perspective on the Complexity of Dietary Fiber Structures and Their Potential Effect on the Gut Microbiota

Bruce R. Hamaker and Yunus E. Tuncil

Whistler Center for Carbohydrate Research, Department of Food Science, Purdue University, 745 Agriculture Mall Drive, West Lafayette, IN 47907-2009, USA

Correspondence to Bruce R. Hamaker: hamakerb@purdue.edu

http://dx.doi.org/10.1016/j.jmb.2014.07.028

Edited by J. L. Sonnenburg

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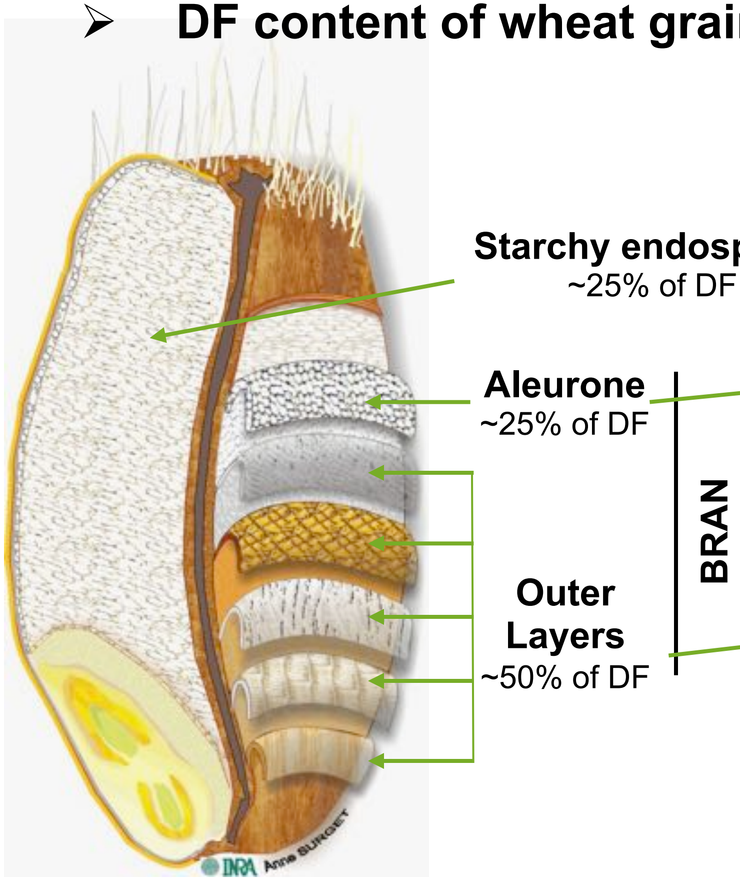
Current Opinion in Biotechnology

Mechanisms of probiosis and prebiosis: considerations for enhanced functional foods

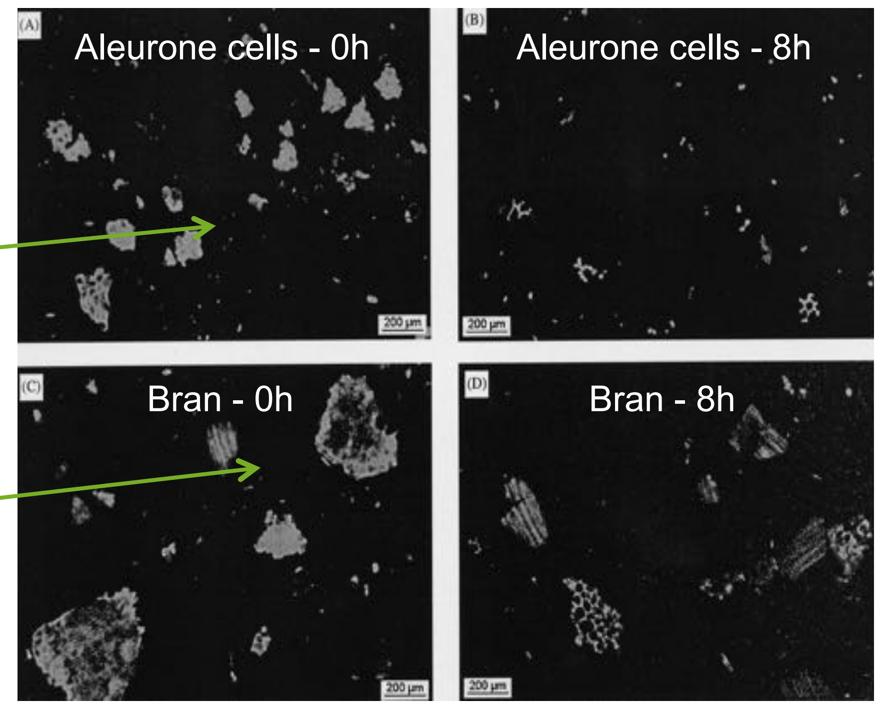
Delphine MA Saulnier[1,4], Jennifer K Spinler[1,4], Glenn R Gibson[3] and James Versalovic[1,2,4]

What are the sources of fermentable DF in wheat grain?

- **DF content of wheat grain: ~15 %**



In vitro incubation with human faeces



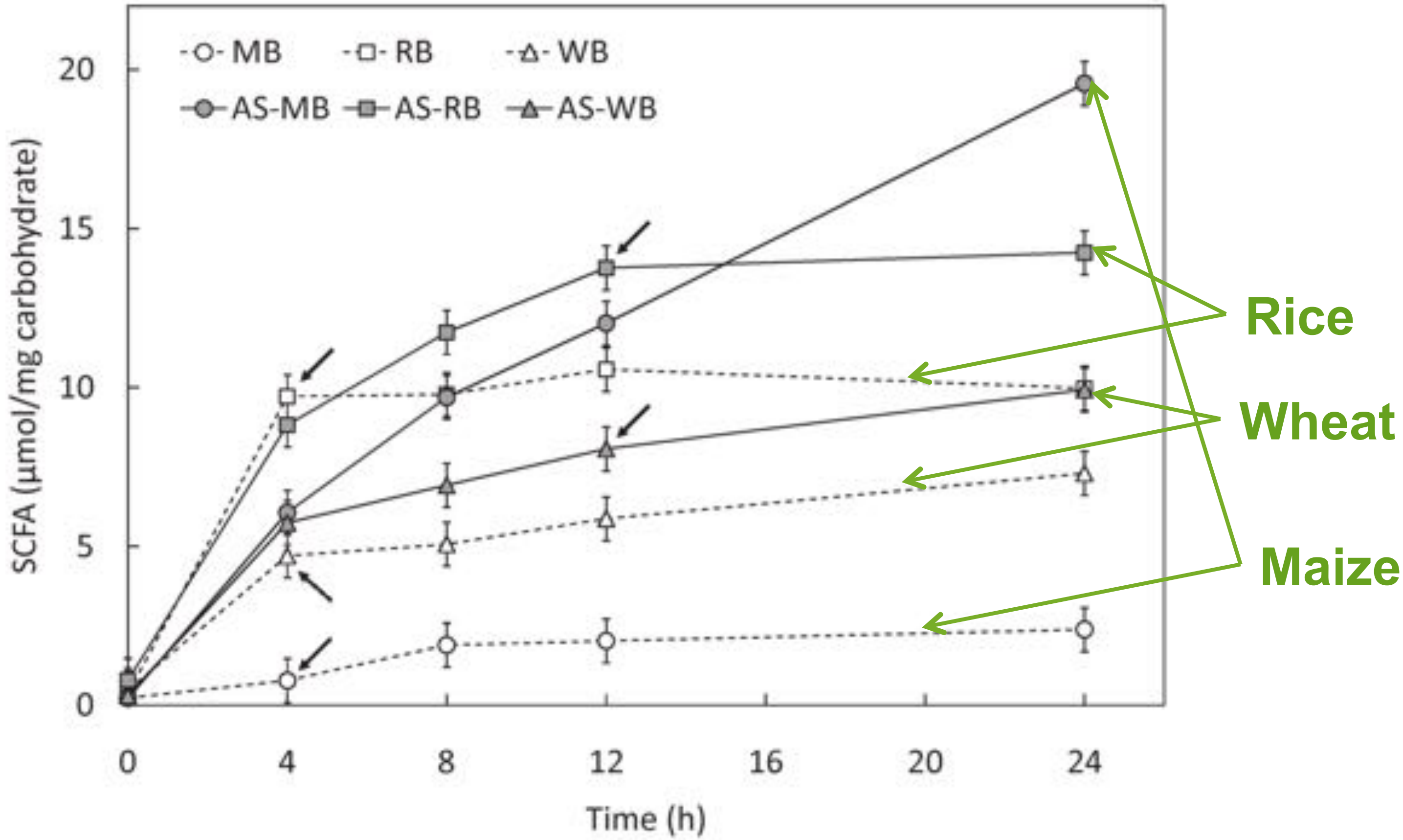
Amrein TM, et al. (2003). *Lebensm. Wissen. Technol.* **36**, 451-460.

JOURNAL OF AGRICULTURAL AND FOOD CHEMISTRY
ARTICLE

J. Agric. Food Chem. 2010, 58, 493–499
DOI:10.1021/jf9020416

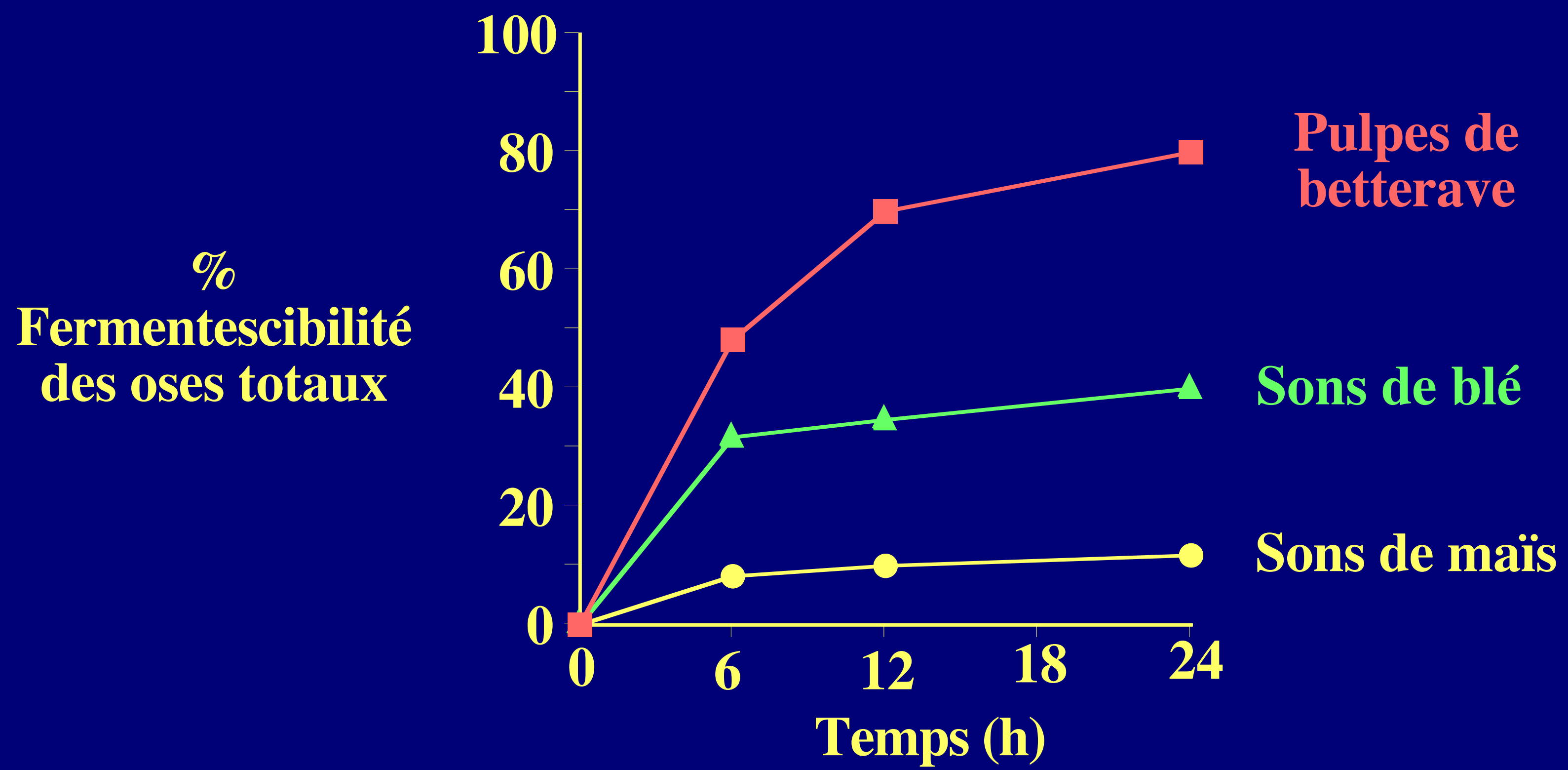
Structural Differences among Alkali-Soluble Arabinoxylans from Maize (*Zea mays*), Rice (*Oryza sativa*), and Wheat (*Triticum aestivum*) Brans Influence Human Fecal Fermentation Profiles

Devin J. Rose,[†,§] John A. Patterson,[‡] and Bruce R. Hamaker[*,†]



Fermentescibilité des fibres de céréales

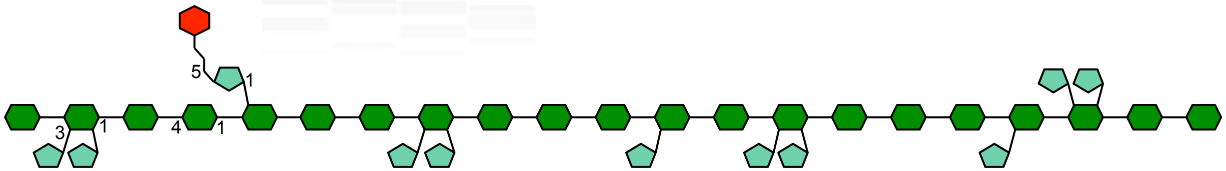
en général faible/fibres d'autres sources



Thèse Valérie Salvador 1993

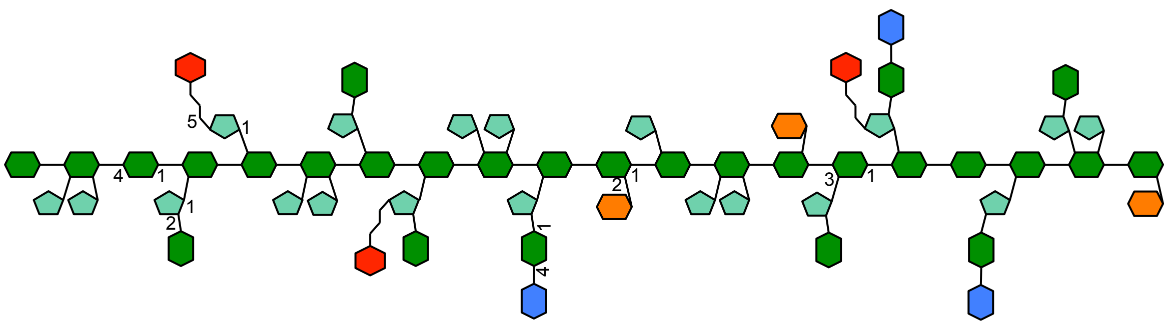
Differences between cereal grain xylans

Large macromolecules: DP >1000



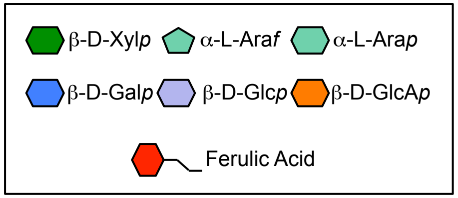
ArabinoXylan (AX) from endosperm

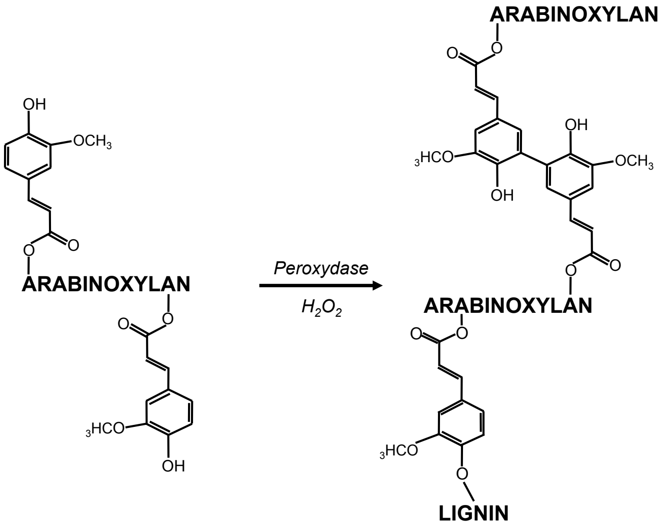
The structure of wheat, barley and rye AX are closely related with similar Ara/Xyl ratio (0.5-0.6). Rye AX have a higher proportion of mono-substitution ( ). Highly branched structure are reported for corn, sorgho and rice endosperm AX (Ara/Xyl ratio ~1)



HeteroXylan (HX) from outer pericarp

Highly branched structure essentially similar in corn, wheat, rye…





MICROBIOLOGY

Wealth management in the gut

NATURE | VOL 500 | 29 AUGUST 2013

People whose guts contain a low diversity of bacteria are found to have higher levels of body fat and inflammation than those with high gut-microbial richness. But dietary intervention can help. SEE ARTICLE P.541 & LETTER P.585

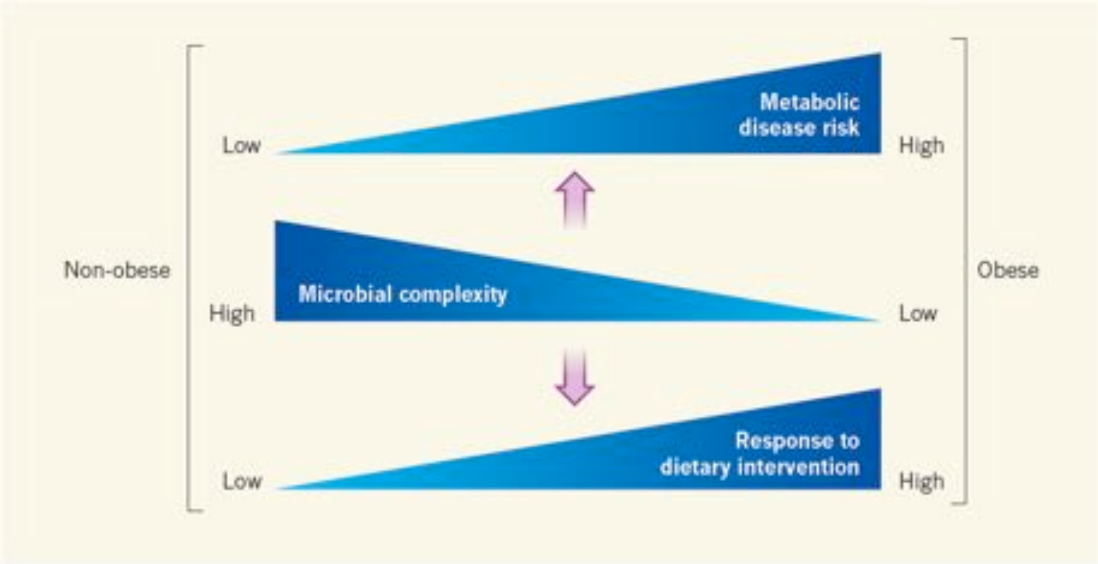


Figure 1 | Benefits of genetic richness. By comparing the complement of microbial genes in the guts of obese and non-obese individuals, Le Chatelier *et al.*[1] show that people with relatively less-complex microbiomes have higher overall body adiposity and more inflammation-associated characteristics, indicating that they are at higher risk of metabolic diseases than people with a greater gut-bacterial richness. Cotillard *et al.*[2] demonstrate that microbial richness increases, and inflammation decreases, in obese and overweight people with low microbial richness who commence an energy-restricted diet, but that such dietary interventions have little effect in individuals with already high microbial richness.

Le Chatelier, et al. (2013). Richness of human gut microbiome correlates with metabolic markers. Nature **500,** 541-546.
Cotillard, A., et al. (2013). Dietary intervention impact on gut microbial gene richness. Nature **500,** 585-588.

Quelles fibres pour la diversité du microbiote?

nutrients MDPI

Article

Effect of Wheat Bran on Fecal Butyrate-Producing Bacteria and Wheat Bran Combined with Barley on *Bacteroides* Abundance in Japanese Healthy Adults

Seiichiro Aoe [1,*], Fumiko Nakamura [2] and Suguru Fujiwara [2]

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2 CPCC Company Limited, 3-3-5 Uchikanda, Chiyoda-ku, Tokyo 101-0047, Japan; f.nakamura@cpcc.co.jp (F.N.); s.fujiwara@cpcc.co.jp (S.F.)
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Received: 2 November 2018; Accepted: 11 December 2018; Published: 14 December 2018 check for updates

Abstract: Wheat bran (WB) is rich in insoluble arabinoxylan, while BARLEYmax (BM) is a barley line that is rich in fructan, resistant starch, and β-glucan. In the present study, we investigated which of these two fiber sources would produce more favorable changes in the fecal variables of healthy subjects. Sixty healthy subjects were randomly divided into four groups ($n = 15$ per group) and fed twice daily for 4 weeks with baked cereal bars containing neither WB nor BM (WB−BM−), WB without BM (WB+BM−), BM without WB (WB−BM+), or WB and BM (WB+BM+). At baseline and after 4 weeks, the fecal microbiota composition and the concentrations of short-chain fatty acids were measured. A significant interactive effect of WB and BM on the abundance of genus *Bacteroides* was observed at week 4. The abundance of butyrate-producing bacteria and the fecal concentration of n-butyrate were significantly higher in the WB+ groups than in the WB− groups. In conclusion, WB was associated with elevated fecal concentrations of short-chain fatty acids including butyrate owing to an increase in the abundance of butyrate-producing bacteria. Additionally, the combination of WB and BM was associated with an increase in the abundance of genus *Bacteroides*. Therefore, both WB alone and WB combined with BM favorably influenced the fecal variables of healthy subjects.

Keywords: wheat bran; BARLEYmax; fecal butyrate; butyrate producer; *Bacteroides*

Nutrients **2018**, *10*, 1980; doi:10.3390/nu10121980

Critical Reviews in Food Science and Nutrition, 51:178–194 (2011)
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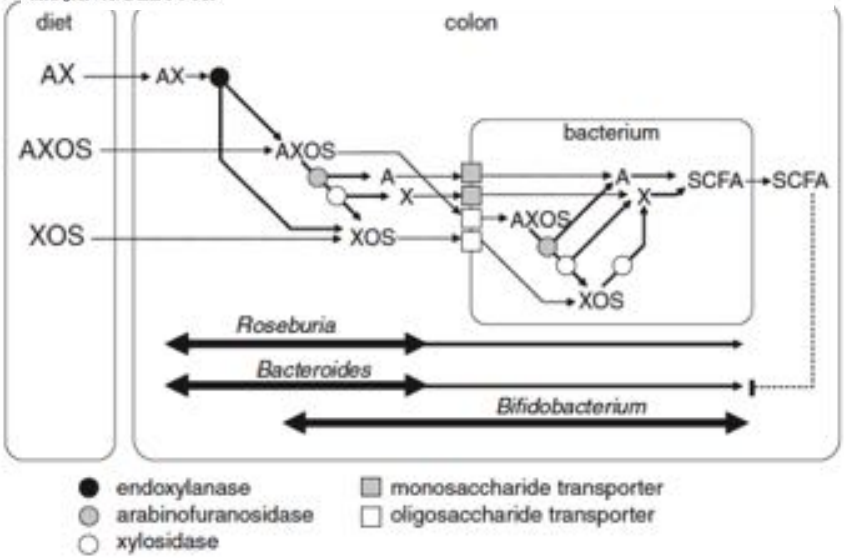
ISSN: 1040-8398 print / 1549-7852 online
DOI: 10.1080/10408390903044768
Taylor & Francis

Prebiotic and Other Health-Related Effects of Cereal-Derived Arabinoxylans, Arabinoxylan-Oligosaccharides, and Xylooligosaccharides

WILLEM F. BROEKAERT,[1] CHRISTOPHE M. COURTIN,[1] KRISTIN VERBEKE,[2] TOM VAN DE WIELE,[3] WILLY VERSTRAETE,[3] and JAN A. DELCOUR[1]

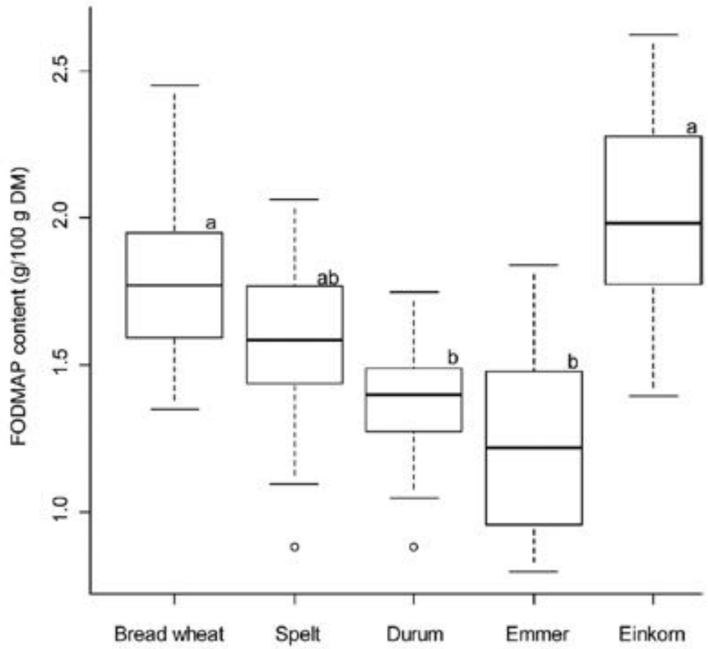


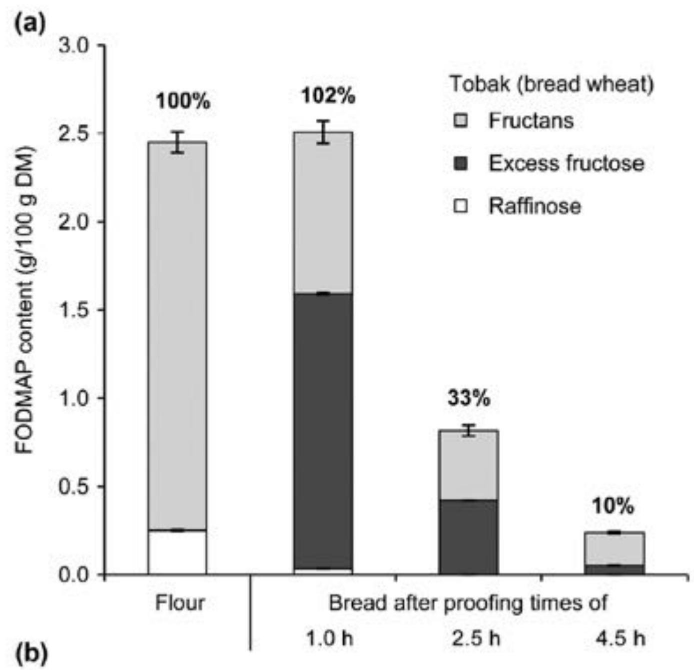
Fructans: good or bad guys ?

Journal of Functional Foods 25 (2016) 257–266
Available online at www.sciencedirect.com
ScienceDirect
journal homepage: www.elsevier.com/locate/jff

Wheat and the irritable bowel syndrome – FODMAP levels of modern and ancient species and their retention during bread making

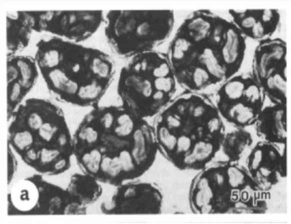
Jochen U. Ziegler [a], Deborah Steiner [a], C. Friedrich H. Longin [b], Tobias Würschum [b], Ralf M. Schweiggert [a,], Reinhold Carle [a,c]*





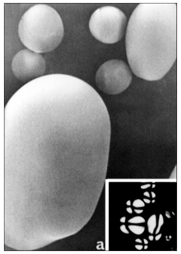
Amidon « digestible » et « résistant »

- **Amidon «digestible»** = amidon digéré dans l'intestin grêle et absorbé sous forme de glucose
- **Amidon «résistant»** = amidon arrivant dans le côlon (fibres alimentaires)



RS1 : amidon physiquement inaccessible

Ex : amidon des légumes secs

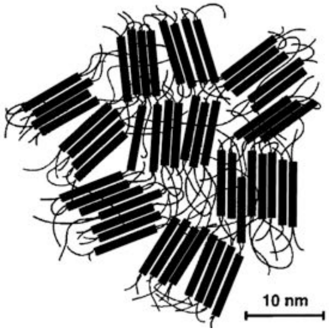


RS2 : grain d'amidon natif naturellement résistant (particulièrement type B)

Ex : amidon de banane, pomme de terre

RS3 : amidon rétrogradé

Ex : amidon riche en amylose



RS4 : amidon chimiquement modifié

La teneur en amidon résistant est faible dans les produits céréaliers

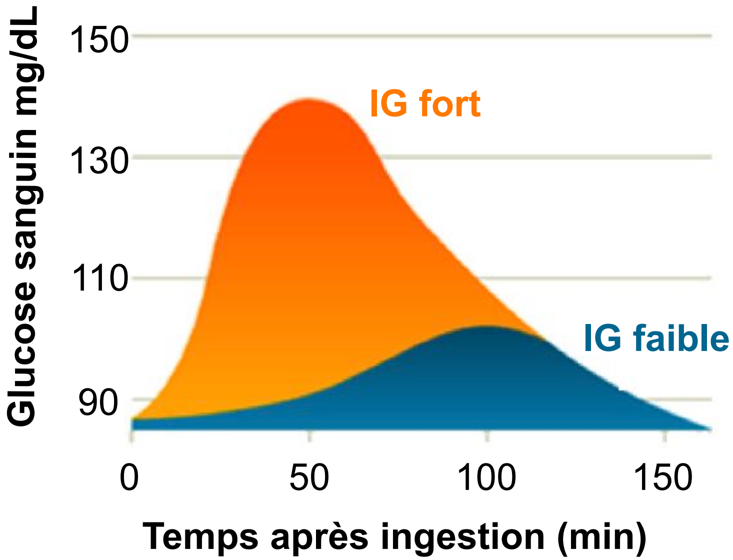
- **L'amidon « résistant »** **est fermenté dans le côlon favorisant la production de butyrate**

	g AR/kg MS
Pains	21,7 ± 1,3
Pâtisseries	22,3 ± 3,7
Pâtes	37,1 ± 3,3
Riz	50,9 ± 2,0
Aliments céréaliers	*32,2 ±1,6*

Brighenti *et al.*, 1998

Effet de la structure de l'aliment sur l'index glycémique

- **L'IG mesure la capacité d'un aliment à élever la glycémie**



IG < 55	faible
55 < IG < 70	moyen
IG > 70	fort

	IG
Baguette	78[a]
Pain de seigle	58[b]
Spaghetti	41[b]

[a] Rizkalla et al., 2007
[b] Liljeberg et al., 1992

Effet Structure

British Journal of Nutrition (2013), 109, 1163–1174
doi:10.1017/S0007114513000032

Journal of Nutrition

Review Article

The effect of dietary fibre on reducing the glycaemic index of bread

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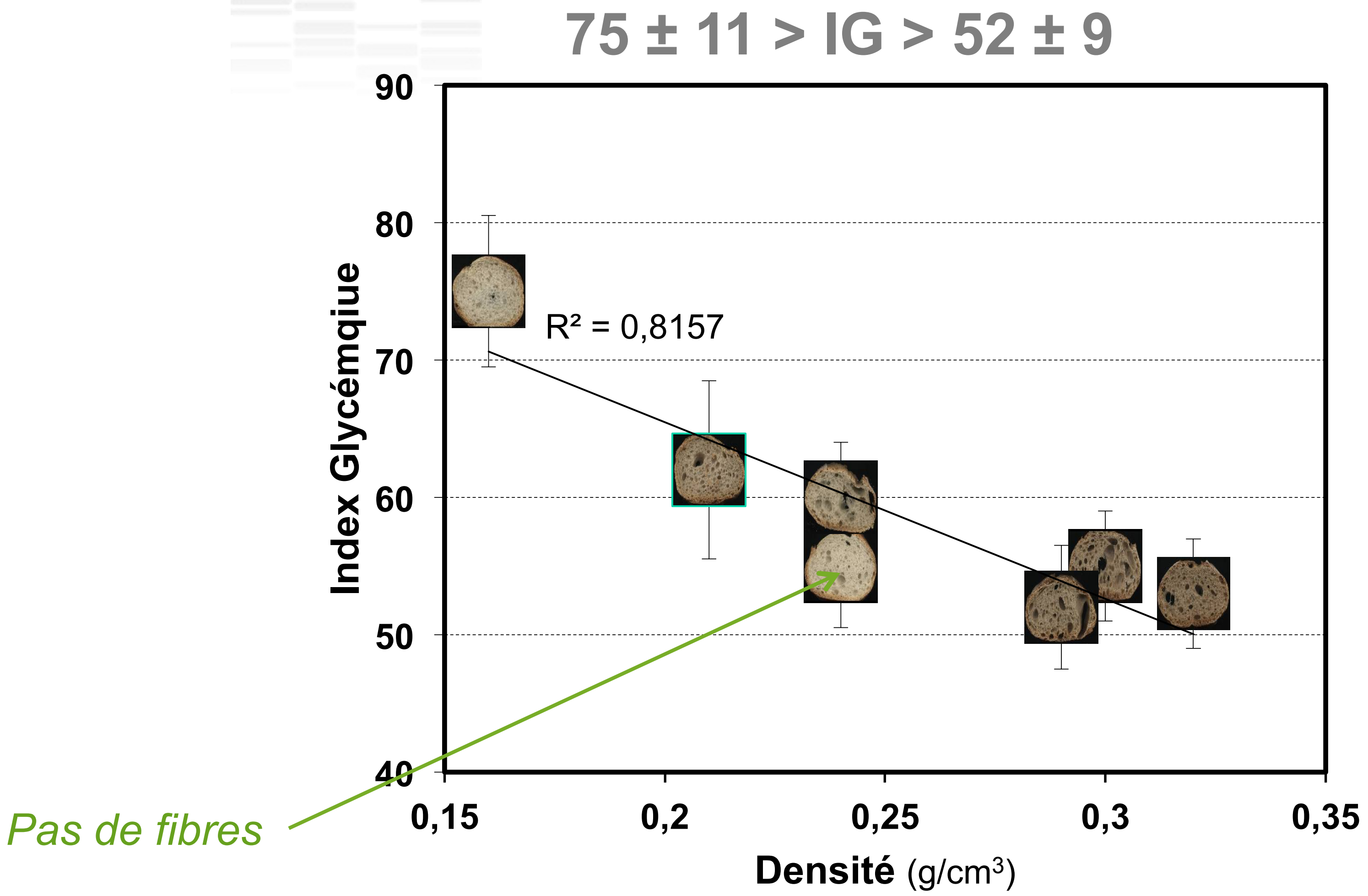
(Submitted 18 April 2012 – Final revision received 19 December 2012 – Accepted 20 December 2012 – First published online 18 February 2013)

Abstract

As bread is the most relevant source of available carbohydrates in the diet and as lowering dietary glycaemic index (GI) is considered favourable to health, many studies have been carried out in order to decrease the GI of bread. The most relevant strategy that has been applied so far is the addition of fibre-rich flours or pure dietary fibre. However, the effectiveness of dietary fibre in bread in reducing the GI is controversial. The purpose of the present review was to discuss critically the effects obtained by adding different kinds of fibre to bread in order to modulate its glycaemic response. The studies were selected because they analysed *in vivo* whether or not dietary fibre, naturally present or added during bread making, could improve the glucose response. The reviewed literature suggests that the presence of intact structures not accessible to human amylases, as well as a reduced pH that may delay gastric emptying or create a barrier to starch digestion, seems to be more effective than dietary fibre *per se* in improving glucose metabolism, irrespective of the type of cereal. Moreover, the incorporation of technologically extracted cereal fibre fractions, the addition of fractions from legumes or of specifically developed viscous or non-viscous fibres also constitute effective strategies. However, when fibres or wholemeal is included in bread making to affect the glycaemic response, the manufacturing protocol needs to reconsider several technological parameters in order to obtain high-quality and consumer-acceptable breads.

Relation entre densité et index glycémique du pain



Original Investigation

JAMA Intern Med. doi:10.1001/jamainternmed.2014.6283
Published online January 5, 2015.

Association Between Dietary Whole Grain Intake and Risk of Mortality
Two Large Prospective Studies in US Men and Women

Hongyu Wu, PhD; Alan J. Flint, MD, ScD; Qibin Qi, PhD; Rob M. van Dam, PhD; Laura A. Sampson, RD; Eric B. Rimm, ScD; Michelle D. Holmes, MD, DrPH; Walter C. Willett, MD, DrPH; Frank B. Hu, MD, PhD; Qi Sun, MD, ScD

CONCLUSIONS AND RELEVANCE These data indicate that higher whole grain consumption is associated with lower total and CVD mortality in US men and women, independent of other dietary and lifestyle factors. These results are in line with recommendations that promote increased whole grain consumption to facilitate disease prevention.

Huang *et al. BMC Medicine* (2015) 13:59
DOI 10.1186/s12916-015-0294-7

BMC Medicine

RESEARCH ARTICLE Open Access

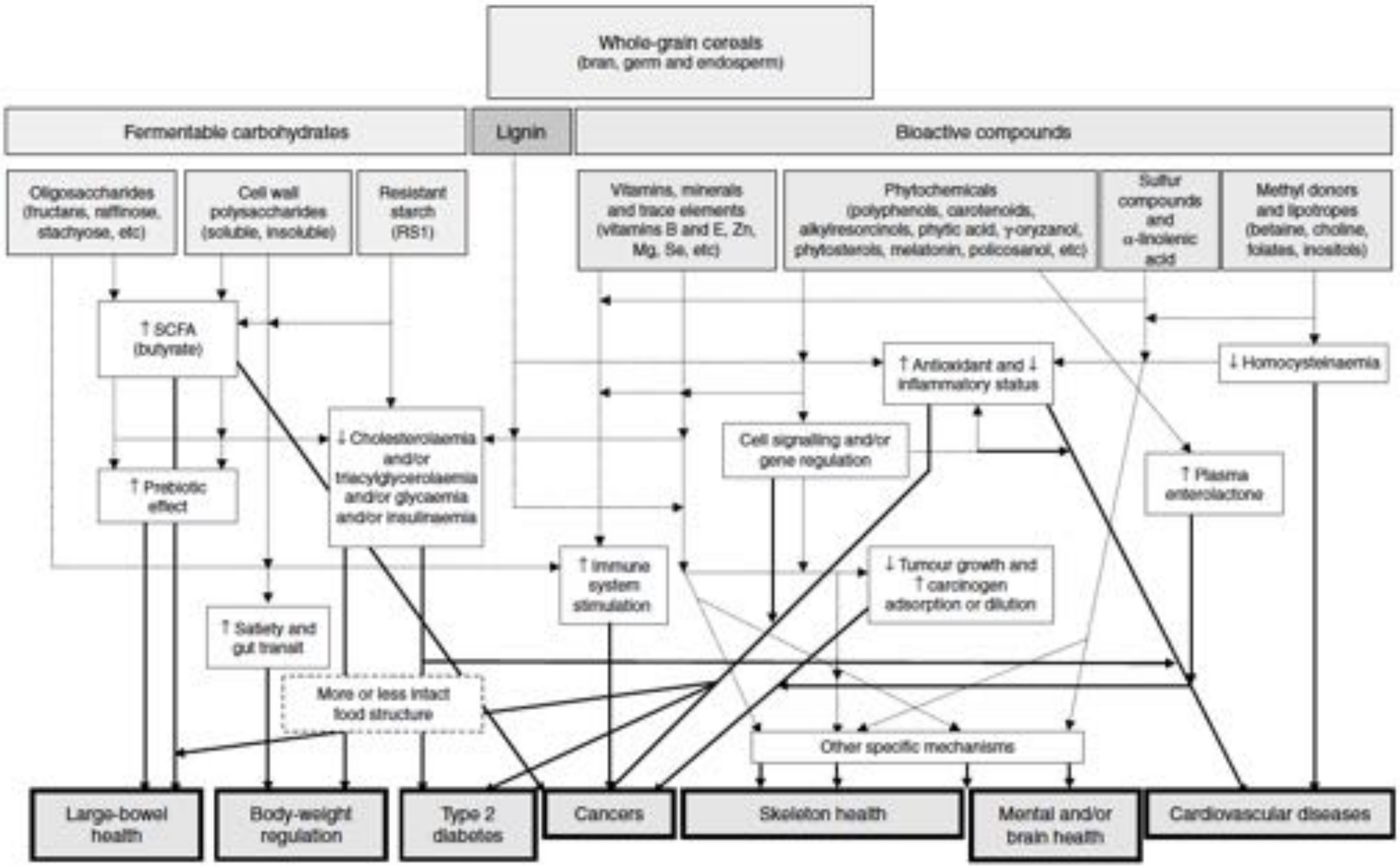
Consumption of whole grains and cereal fiber and total and cause-specific mortality: prospective analysis of 367,442 individuals

Tao Huang[1], Min Xu[1], Albert Lee[2], Susan Cho[3] and Lu Qi[1,4*]

Conclusions: Consumption of whole grains and cereal fiber was inversely associated with reduced total and cause-specific mortality. Our data suggest cereal fiber is one potentially protective component.

New hypotheses for the health-protective mechanisms of whole-grain cereals: what is beyond fibre?

Fardet A. (2010) *Nutrition Research Reviews* **23**, 65-134



CONCLUSIONS

- **Une large diversité des fibres alimentaires dans les céréales**
  - Les FA solubles et visqueuses ont des effets nutritionnels reconnus
  - L'effet sur le microbiote est très important mais pas l'unique mécanisme de leur action: Fibres purifiées ≠ Fibres « originales » et **quelles associations optimales pour la diversité du microbiote**?
  - Les composés phytochimiques associés à la paroi ont des effets bénéfiques sur la santé (**Whole grain**) mais **question des contaminants à clarifier**

- **Comment augmenter la teneur et améliorer les propriétés des fibres des produits céréaliers**
  - Technologie du fractionnement/ enrichissement en couches à aleurone/ combinaison possible avec la technologie enzymatique
  - La sélection variétale : potentiellement réalisable pour AX et BG
  - Amidon résistant : AR = process – Amidon riche en amylose + propice à former de l'AR - Amylose/amylopectine +lipides

LA CONSOMMATION DE PAIN COMPLET EN FRANCE

Tableau 38. Taux de consommateurs, consommations journalières moyennes et contribution à la ration journalière par groupe d'aliments, selon l'âge, pour les adultes de 18 à 79 ans (n=2 121)

Groupe d'aliments	Age	Taux de consommateurs[1]			Consommation (g/j)				Contribution à la ration journalière		
		%	[IC à 95%]	Test	Moy.	Ecart-Type	Médiane	Test moy.	%	Ecart-Type	Test
Pain et panification sèche raffinés	18-44 ans	90,2	[86,8-92,8]	**	93,0	80,2	69,3	***	3,24	2,92	***
	45-64 ans	94,9	[92,6-96,5]		121,3	103,4	95,8		4,03	3,27	
	65-79 ans	95,9	[92,9-97,7]		119,8	122,8	90,0		4,48	4,44	
Pain et panification sèche complets ou semi-complets	18-44 ans	15,4	[12,2-19,1]	ns	6,0	16,7	0,0	ns	0,20	0,58	ns
	45-64 ans	17,4	[13,8-21,7]		6,9	24,0	0,0		0,23	0,79	
	65-79 ans	15,0	[12,0-18,5]		6,3	24,6	0,0		0,21	0,83	

- Compromis « difficile » entre bénéfices santé et acceptabilité par le consommateur
- Comment améliorer la consommation de fibres dans les produits céréaliers
  - Retour des produits/procédés traditionnels (fermentation) / nouveaux produits
  - Education des consommateurs
  - *Exploration de mélange de fibres (hors céréales) qui augmente la diversité microbienne tout en préservant la qualités sensorielle des produits-*