

The potential role of oats in a gluten-free diet

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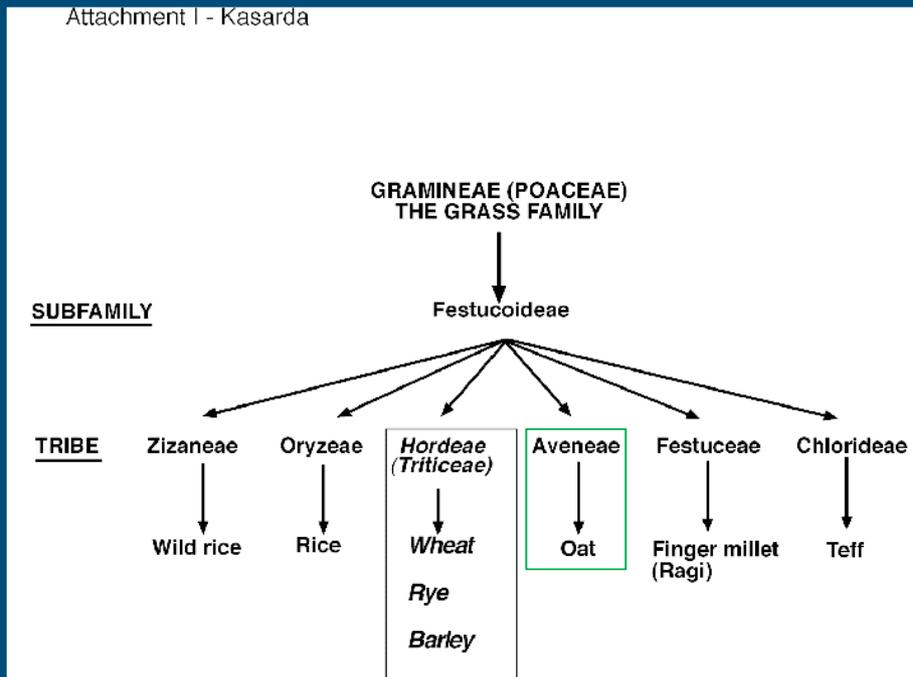
Content

- The crop
- Nutrition and health
 - Compounds
 - Claims and Patents
- Potentials in gluten-free
- Conclusions



Oat within the grass family

Attachment I - Kasarda



Wheat, rye and barley are the gluten-containing cereals

The grain

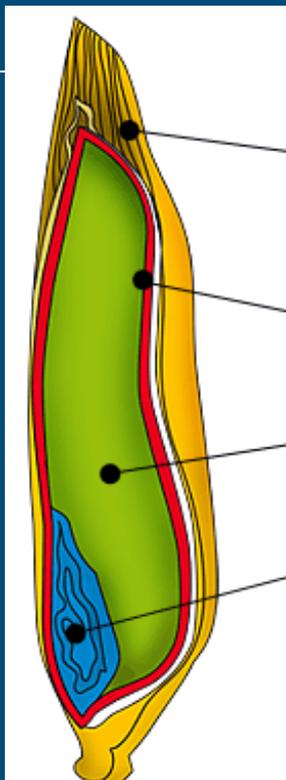
Hull

Bran

Endosperm

Germ

'whole grain':
'Bran + Endosperm + Germ



De schil

- Vezelig beschermende laag
- oneetbaar
- Wordt verwijderd tijdens bewerking.

Zemel (BRAN)

De zemel is de beschermende laag om de graankorrel en levert voedingsvezels voor menselijke consumptie.

Endosperm

Het endosperm is voor de groeiende plant de bron van zetmeel en eiwitten. Het is dus een energiebron. **Olie, vetzuren**

Kiem

De kiem bevat de zaai vrucht van het graan. Dit is een belangrijke bron van vitaminen, mineralen en eiwitten.

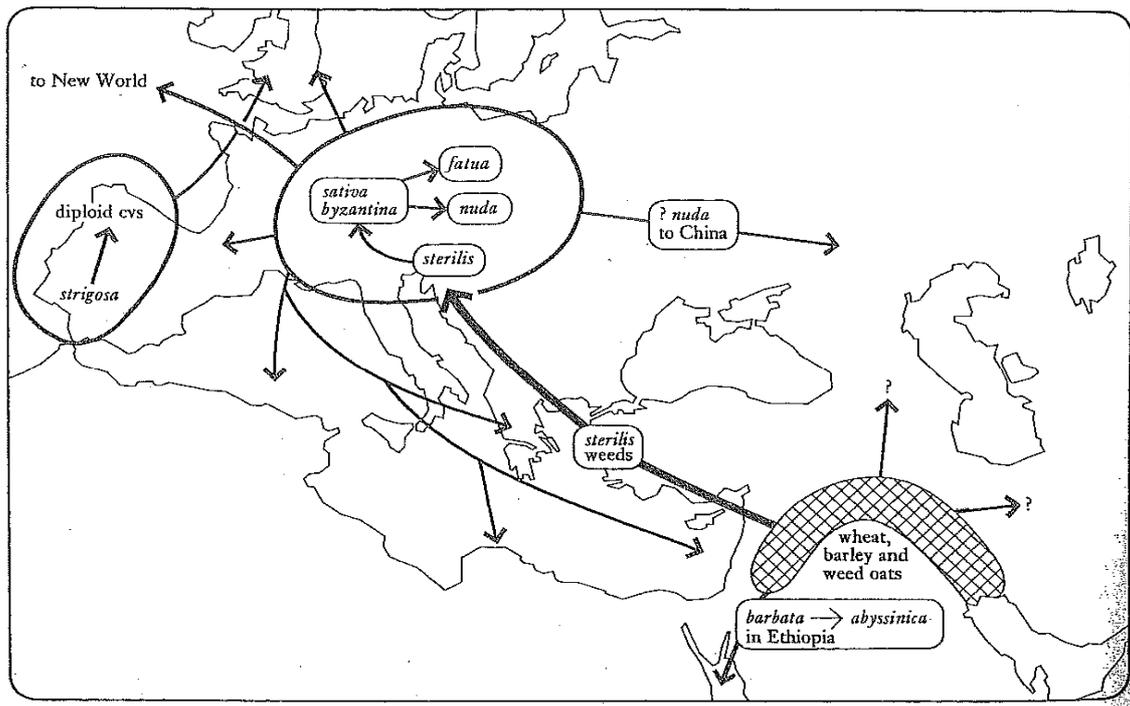


Avena sativa history

- 9000 y ago: domestication of wheats (einkorn, emmer), barley and pulses as 'crops' in Fertile Crescent; oat was a weed
- Move of these crops with farmers to Europe
- 3000 y ago: **Domestication of oat in NW-Europe**
- Oat grows best in cool, moist, maritime climates
- 2000 y ago: Hexaploid oat (*Avena sativa*) is a major crop in Europe

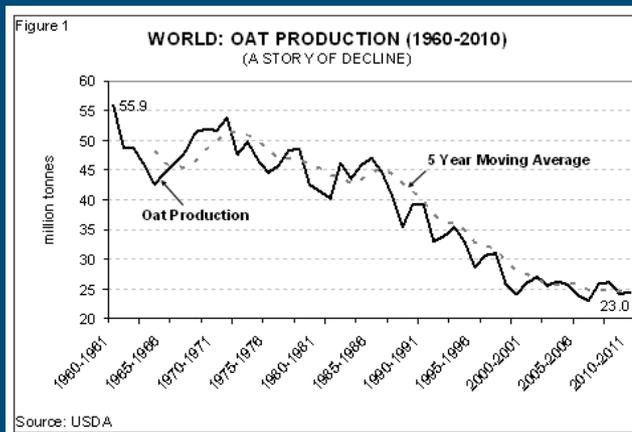
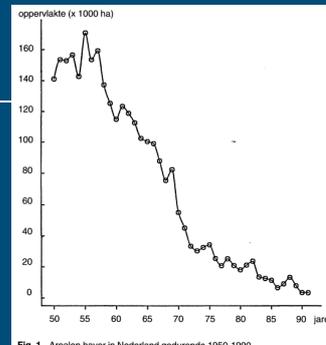
Oat is OUR crop

Fig. 28.2 Evolutionary geography of the cultivated oats, *Avena*.



Oat, current status

- 1850: Selections of spring and winter oat landraces
- 1960: Decline
- 2000: Increased attention: health



Regain of interest: Oat brings health

- Field
- Feed
- Food
- Total health package



Field

Advantages

- Robust and sustainable
 - Low N need (equal yields on sand and clay)
 - Low sensitivity to diseases
 - Fits well in several crop rotations
 - Positive effects on soil health (combatting nematodes)
 - Performs well in organic agriculture

Challenge

- Yield and profit
 - Potentials as breaker crop



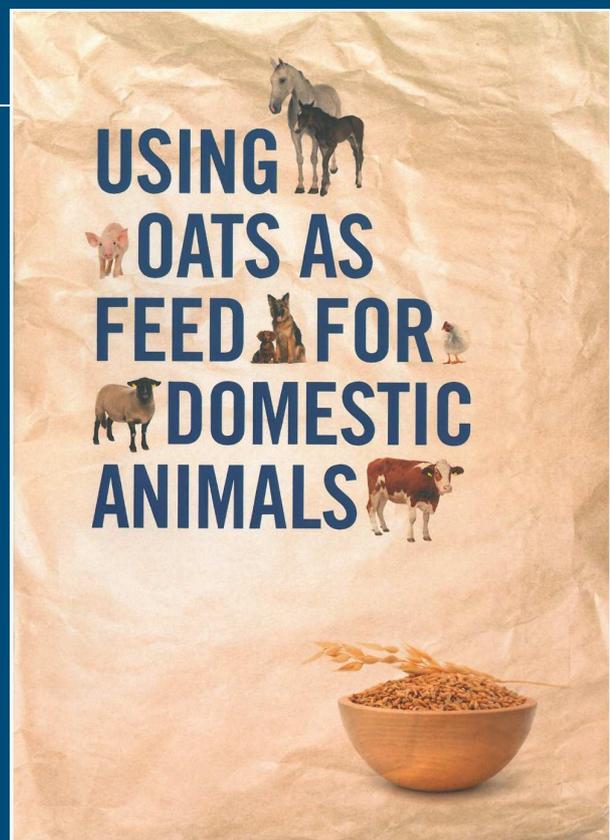
Feed

Advantages

- Promoting intestinal health
- Increasing immunity (help in reduction of antibiotics)
- Rich in energy
- Keeps animals quiet (satiety)
- Weight control

Challenge

- Competition with other cereals (maize, wheat) and soy



Food: nutritious and healthy

- Starch
- Proteins
- Lipids
- Fibre
- Phenolics
- Vitamins
- Minerals



Human health: what are the issues?

- Chronic diseases:
 - Cardiovascular diseases
 - Diabetes
 - Obesity
 - Cancer
 - Respiratory diseases
 - Immune-related diseases
 - Allergies
 - Coeliac disease 



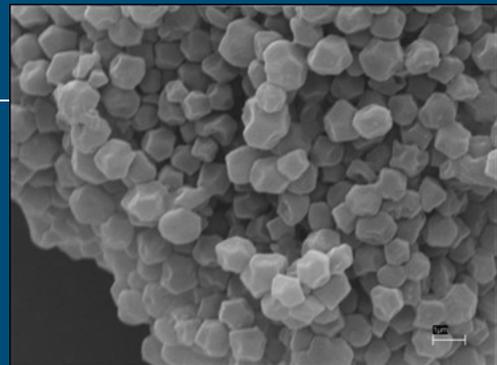
Easy to prevent

- Avoidance of tobacco
- Healthy diet
- Regular physical activity
- Oats can contribute



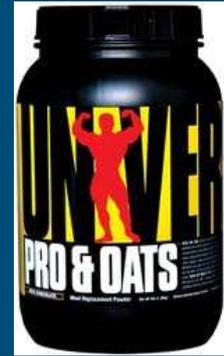
Starch

- Total starch: 60%
- Unique small particle size
- Small amylose chain length
- Low solubility
- Slow and complete digestibility
- Low glycaemic index also due to high soluble fibre content
- Helps in diabetes and obesitas



Proteins

- Total protein : 15-20% (highest among cereals)
- Globulins (80%), albumins, avenins
- Digestibility: very high
- Rich in essential amino acids
 - Only lysine and threonine are 20% below the FAO standard
 - Lysine is relatively high as compared to other cereals
- Fit in GFD 
- WHO: equal quality to meat, milk, egg protein

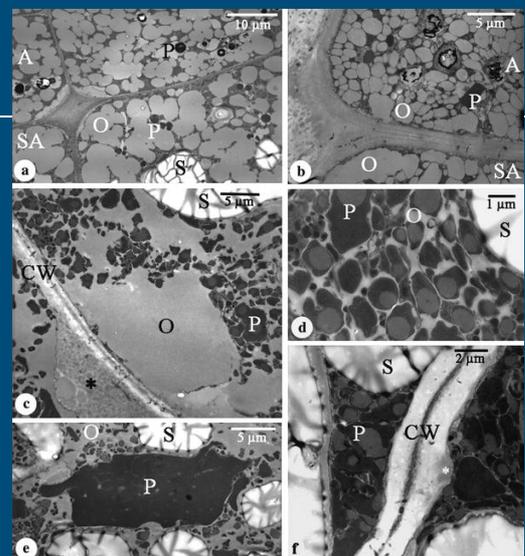


prOATein™



Lipids

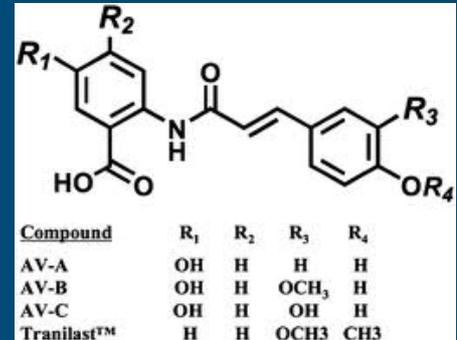
- Total lipid content: 7% average (5.6 - 8.2%), some (naked oat) varieties: 15%
- Unique in cereal endosperm
- Unsaturated fatty acids: ~80%
 - (C14:0) 2 (myristic acid)
 - (C16:0) 18 (palmitic acid)
 - (C18:0) 2 (stearic acid)
 - (C18:1) 35 (oleic acid)
 - (C18:2) 40 (linoleic acid)
 - (C18:3) 2 (linolenic acid)
 - (C20:1) 1 (eicosenoic acid)
- Lipids may reduce sensory quality (heat processing required)
- Reducing risk of heart and vascular diseases
- Skin care



Phenolics

■ Avenanthramides are unique to oats

- Taken up into the blood stream
- Strong anti-oxidant activity
- Prophylactic against arteriosclerosis, cardiovascular diseases, certain cancers
- May reduce inflammation (applied as anti-allergic antihistamine drug)

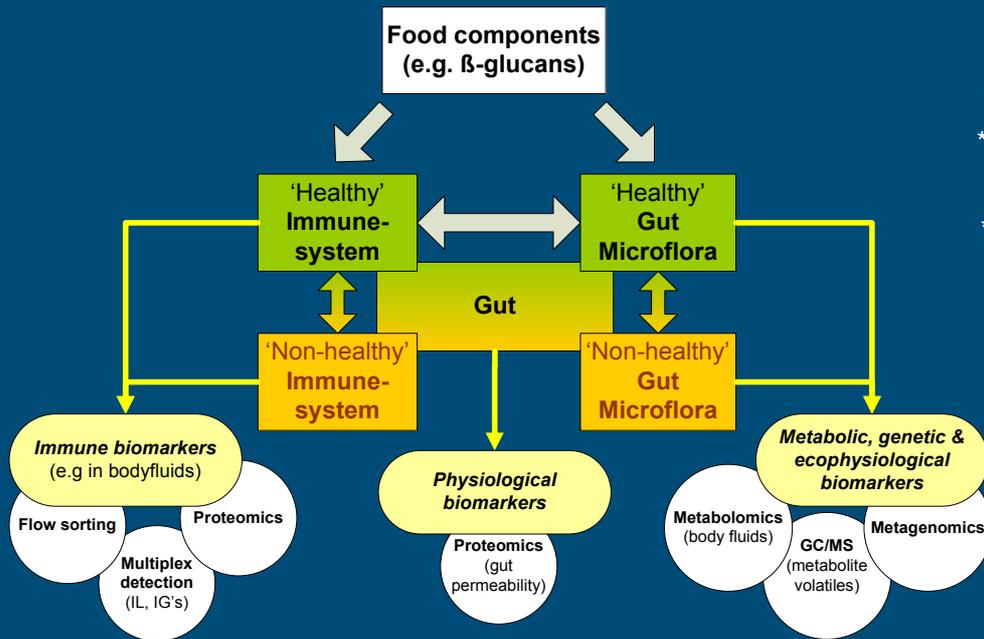


Dietary fibres in general (Wikipedia)

- **Both** Applies to both soluble and insoluble fiber
- **Soluble** Applies to soluble fiber only
- **Insoluble** Applies to insoluble fiber only

Effects ^{[60][61]}
Increases food volume without increasing caloric content, providing satiety which may reduce appetite.
Attracts water and forms a viscous gel during digestion, slowing the emptying of the stomach and intestinal transit, shielding carbohydrates from enzymes, and delaying absorption of glucose, ^[62] which lowers variance in blood sugar levels
Lowers total and LDL cholesterol, which may reduce the risk of cardiovascular disease
Regulates blood sugar, which may reduce glucose and insulin levels in diabetic patients and may lower risk of diabetes ^[63]
Speeds the passage of foods through the digestive system, which facilitates regular defecation
Adds bulk to the stool, which alleviates constipation
Balances intestinal pH ^[64] and stimulates intestinal fermentation production of short-chain fatty acids, which may reduce risk of colorectal cancer ^[65]

Dietary fibres

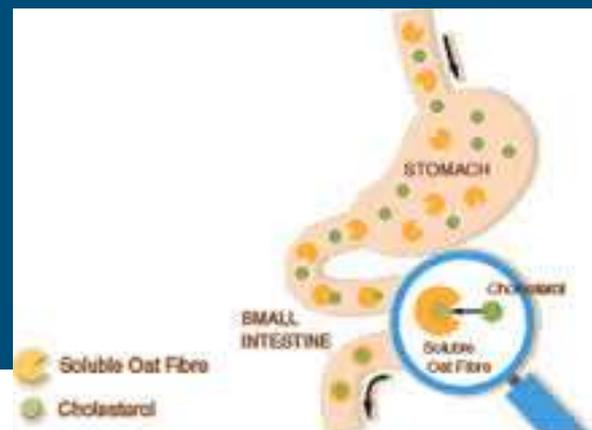
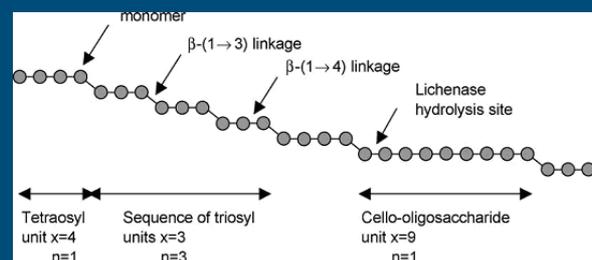
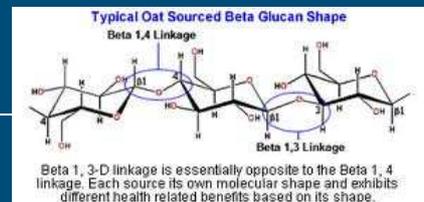


Role of beta-glucans in intestinal health:

- * Direct effect on immune system
- * Indirect effects through gut microflora

Fibres: oat beta glucan

- Total fibre ~8% of which
 - 58% soluble fibre (mainly beta-glucans)
- Formation of highly viscous gums
- Retarding stomach emptying
 - Improving digestion
 - Decreasing postprandial glucose responses
- May prolong satiety
 - Decrease insulin secretion
 - Keep cholecystokinin (CCK) level elevated
- Binding cholesterol in intestine
 - Reducing LDL-C in blood
 - Official FDA and EFSA health claims



Official EFSA Health Claims:

■ Two main types

- Article 13. Health claims other than those referring to the reduction of disease risk (i.e. general function claims): EC Regulation 432/2012
- Article 14. Reduction of disease risk claims (EC Regulation 1924/2006; 1160/2011)

Claim 1 (EC 432/2012)

Beta-glucans

Beta-glucans contribute to the maintenance of normal blood cholesterol levels

The claim may be used only for food which contains at least 1 g of beta-glucans from oats, oat bran, barley, barley bran, or from mixtures of these sources per quantified portion. In order to bear the claim information shall be given to the consumer that the beneficial effect is obtained with a daily intake of 3 g of beta- glucans from oats, oat bran, barley, barley bran, or from mixtures of these beta-glucans.

Claim 2 (EC 432/2012)

Beta-glucans from oats and barley

Consumption of beta- glucans from oats or barley as part of a meal contributes to the reduction of the blood glucose rise after that meal

The claim may be used only for food which contains at least 4 g of beta-glucans from oats or barley for each 30 g of available carbohydrates in a quantified portion as part of the meal. In order to bear the claim information shall be given to the consumer that the beneficial effect is obtained by consuming the beta-glucans from oats or barley as part of the meal.

Claim 3 (EC 432/2012)

Oat grain fibre

Oat grain fibre contributes to an increase in faecal bulk

The claim may be used only for food which is high in that fibre as referred to in the claim HIGH FIBRE as listed in the Annex to Regulation (EC) No 1924/2006.

Claim 4 (EC 432/2012)

Foods with a low or reduced content of saturated fatty acids

Reducing consumption of saturated fat contributes to the maintenance of normal blood cholesterol levels

The claim may be used only for food which is at least low in saturated fatty acids, as referred to in the claim LOW SATURATED FAT or reduced in saturated fatty acids as referred to in the claim REDUCED [NAME OF NUTRIENT] as listed in the Annex to Regulation (EC) No 1924/2006.



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Claim 5 (EC 1160/2011)

Oat beta-glucan

Oat beta-glucan has been shown to lower/reduce blood cholesterol. High cholesterol is a risk factor in the development of coronary heart disease.

Information shall be given to the consumer that the beneficial effect is obtained with a daily intake of 3 g of oat beta-glucan. The claim can be used for foods which provide at least 1 g of oat beta glucan per quantified portion.



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Patent claims related to beta-glucan

- Promoting cardiovascular health
- Lowering cholesterol / treatment of hypercholesterolemia; prevention of hyperlipidaemia
- Treatment of diabetes
- Treatment of obesity / weight management
- Promoting gastrointestinal health
- Use as vaccine or immunostimulant



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Oats in the USA

- Health-related USA claims (FDA)
 - Health claims
 - Structure/function claims
 - Nutrient content claims



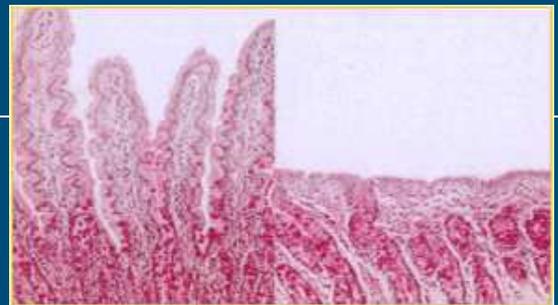
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Authorized health claims that oat products may utilize

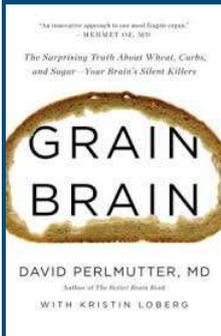
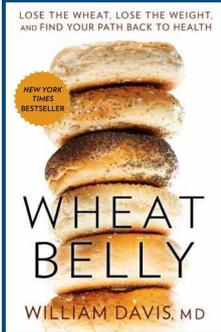
- Oat soluble fibre and the **reduced risk of coronary heart disease**
- Whole-grain claims based on authoritative statements
 - On risk of **heart disease and certain cancers**
- Potential claim evidence for oats and **diabetes risk reduction and diabetes management**
- Potential claim evidence for oats and **satiety and weight loss effects**
- Potential claim evidence for whole grains and **weight management**
- Potential claim evidence for oats and **blood pressure effects**

Oats and Coeliac Disease

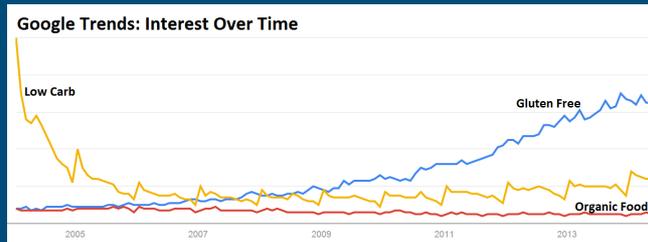
- Gluten intolerance
 - wheat, rye, barley
- T-cell mediated small intestinal disorder (chronic inflammation)
- Variety of Symptoms
 - diarrhea, fatigue, weight loss, stomach pain, malabsorption, chronic headache, ataxia, osteoporosis, dermatitis herpetiformis, reduced fertility, abortion, lymphoma
- 1-3% of the Western population
- Life-long gluten-free diet 



Global change towards negative appreciation of common wheat

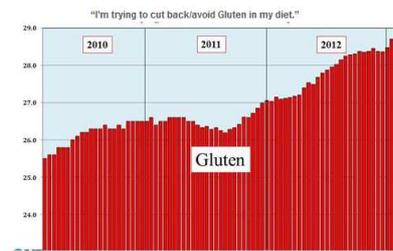


- Increased awareness on healthy diets (no fast foods)
- No gluten consumption
- Non-coeliac wheat/gluten sensitivity: what is it? 6-10% of the population?
- Increased attention for tradition: old wheat species and alternative (gluten-free) grains like **oats**



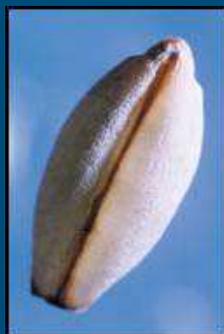
—200 million restaurant visits include a gluten-free order

Chicago, March 6, 2013—As of this January about a third of U.S. adults say they want to cut down or be free of gluten in their diets, the highest percentage making this claim since The NPD Group, a leading global information company, began asking the question in 2009. NPD's *Dieting Monitor*, which continually tracks on a bi-weekly basis top-of-mind dieting and nutrition-related issues facing consumers, reports that 30 percent of adults, one in every three adults, claimed to cut down on or avoid gluten completely in January 2013.



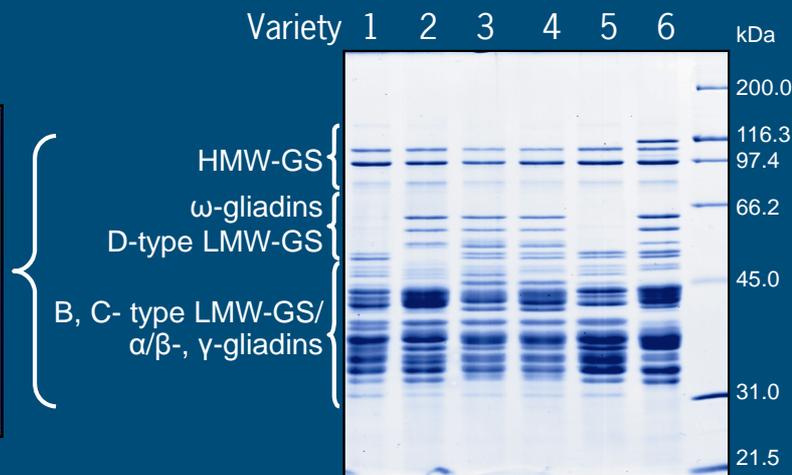
Source: The NPD Group/Dieting Monitor, 52 week data year ending January 30, 2013

Gluten proteins in wheat



~70% starch

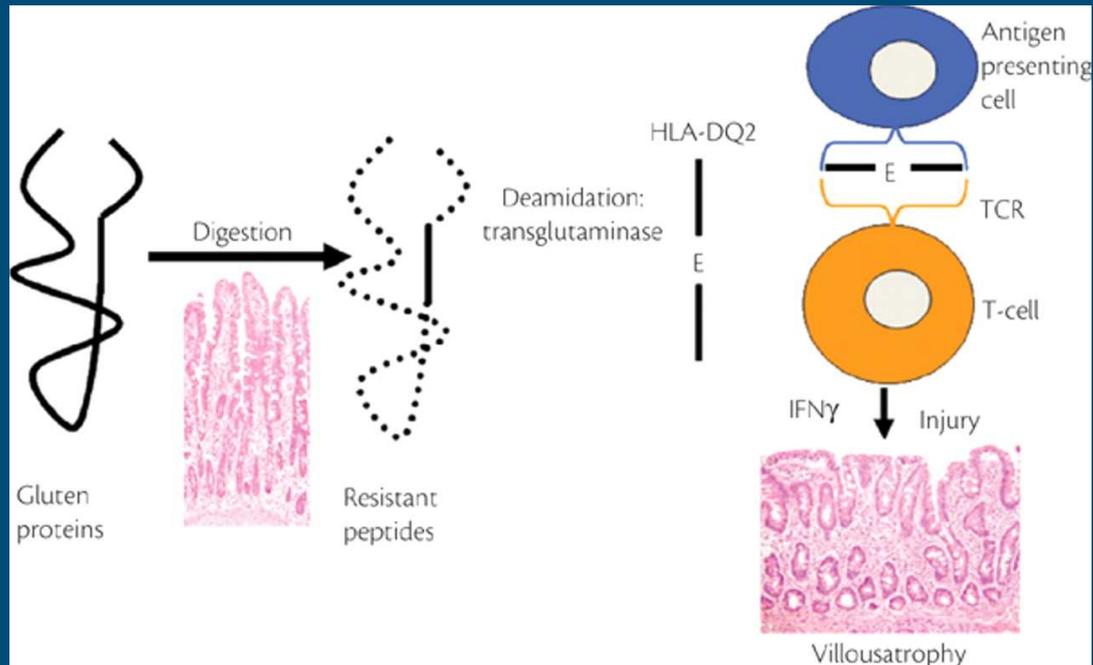
8-15% protein, mainly gluten



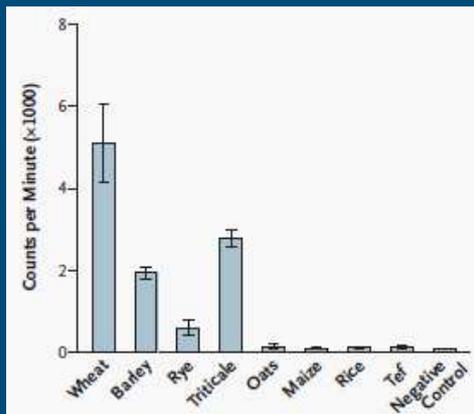
SDS-PAGE (CBB)

HMW-GS: high molecular weight glutenin subunit; LMW-GS: low molecular weight glutenin subunit

Gluten digestion



Oats and coeliac disease



T-cell stimulation (Koning et al., 2005)

Table 2 List of celiac disease relevant T-cell epitopes recognized by CD4⁺ T cells

Epitope ^a	Previous names	Peptide-binding register ^b									Reference
		1	2	3	4	5	6	7	8	9	
DQ2.5 restricted epitopes											
DQ2.5-glia-t1a	DQ2-a-I, a9	P	F	P	Q	P	E	L	P	Y	(Arentz-Hansen et al. 2000)
DQ2.5-glia-t1b	DQ2-a-III	P	Y	P	Q	P	E	L	P	Y	(Arentz-Hansen et al. 2002)
DQ2.5-glia-a2	DQ2-a-II, a2	P	Q	P	E	L	P	Y	P	Q	(Arentz-Hansen et al. 2000)
DQ2.5-glia-a3	glia-a20	F	R	P	E	Q	P	Y	P	Q	(Vader et al. 2002b)
DQ2.5-glia-y1	DQ2-γ-1	P	Q	Q	S	F	P	E	Q	Q	(Sjöström et al. 1998)
DQ2.5-glia-γ2	DQ2-γ-4I, γ30	I	Q	P	E	Q	P	A	Q	L	(Qiao et al. 2005; Vader et al. 2002b)
DQ2.5-glia-γ3	DQ2-γ-4III	Q	Q	P	E	Q	P	Y	P	Q	(Arentz-Hansen et al. 2002)
DQ2.5-glia-γ4a	DQ2-γ-4V	S	Q	P	E	Q	E	F	P	Q	(Arentz-Hansen et al. 2002)
DQ2.5-glia-γ4b	DQ2-γ-VIIc	P	Q	P	E	Q	E	F	P	Q	(Qiao et al. 2005)
DQ2.5-glia-γ4c	DQ2-γ-VIIa	Q	Q	P	E	Q	P	F	P	Q	(Arentz-Hansen et al. 2002)
DQ2.5-glia-γ4d	DQ2-γ-VIIb	P	Q	P	E	Q	P	F	C	Q	(Qiao, unpublished)
DQ2.5-glia-γ5	DQ2-γ-VI	Q	Q	P	F	P	E	Q	P	Q	(Arentz-Hansen et al. 2002)
DQ2.5-glia-a1	DQ2-a-I	P	F	P	Q	P	E	Q	P	F	(Tye-Din et al. 2010)
DQ2.5-glia-a2	DQ2-a-II	P	Q	P	E	Q	P	F	P	Q	(Tye-Din et al. 2010)
DQ2.5-gliat-L1	glutenin-17	P	F	S	E	Q	E	Q	P	V	(Vader et al. 2002b)
DQ2.5-gliat-L2	glutenin-156	F	S	Q	Q	Q	E	S	P	F	(Stepniak et al. 2005; Vader et al. 2002b)
DQ2.5-hor-1	Hor-a2, Hα9	P	F	P	Q	P	E	Q	P	F	(Tye-Din et al. 2010; Vader et al. 2003a)
DQ2.5-hor-2	Hor-a2, Hα2	P	Q	P	E	Q	P	F	P	Q	(Vader et al. 2003a)
DQ2.5-hor-3	hor-1-DQ2	P	I	P	E	Q	P	Q	P	Y	(Tye-Din et al. 2010)
DQ2.5-sec-1	Sec-a9, Sα9	P	F	P	Q	P	E	Q	P	F	(Tye-Din et al. 2010; Vader et al. 2003a)
DQ2.5-sec-2	Sec-a2, Sα2	P	Q	P	E	Q	P	F	P	Q	(Vader et al. 2003a)
DQ2.5-ave-1a	Av-a9A	P	Y	P	E	Q	E	E	P	F	(Arentz-Hansen et al. 2004; Vader et al. 2003a)
DQ2.5-ave-1b	Av-a9B, 1490	P	Y	P	E	Q	E	Q	P	F	(Arentz-Hansen et al. 2004; Vader et al. 2003a)
DQ2.2 restricted epitopes											
DQ2.2-gliat-L1	glutenin-17	P	F	S	E	Q	E	Q	P	V	(Bodd et al. 2012)
DQ8 restricted epitopes											
DQ8-glia-a1	DQ8-a-1	E	G	S	F	Q	P	S	Q	E	(van de Wal et al. 1998b)
DQ8-glia-t1a	DQ8-t-1a	E	Q	P	Q	Q	P	F	Q	(Tollefsen et al. 2006)	
DQ8-glia-t1b	DQ8-t-1b	E	Q	P	Q	Q	P	Y	P	E	(Tollefsen et al. 2006)
DQ8-gliat-HI	HMW-glutenin	Q	G	Y	Y	P	T	S	P	Q	(van de Wal et al. 1999)
DQ8.5 restricted epitopes											
DQ8.5-glia-t1	DQ8-a-1	E	G	S	F	Q	P	S	Q	E	(Kooy-Winkelhar et al. 2011)
DQ8.5-glia-γ1		P	Q	Q	S	F	P	E	Q	E	(Kooy-Winkelhar et al. 2011)
DQ8.5-gliat-HI	HMW-glutenin	Q	G	Y	Y	P	T	S	P	Q	(Kooy-Winkelhar et al. 2011)

- Safe cereal for >99% of people with CD (Pulido et al., 2009)
- Epitopes in wheat, barley and rye are all absent from oat (Londono et al., 2013)
- Consumption of oats stimulates digestion in people with CD (Kaukinen et al., 2013; Gatti et al., 2013): "the more and the longer, the better"
- 100 g/day no intestinal damage → oats can safely be included in GFD (Hardy et al., 2015)

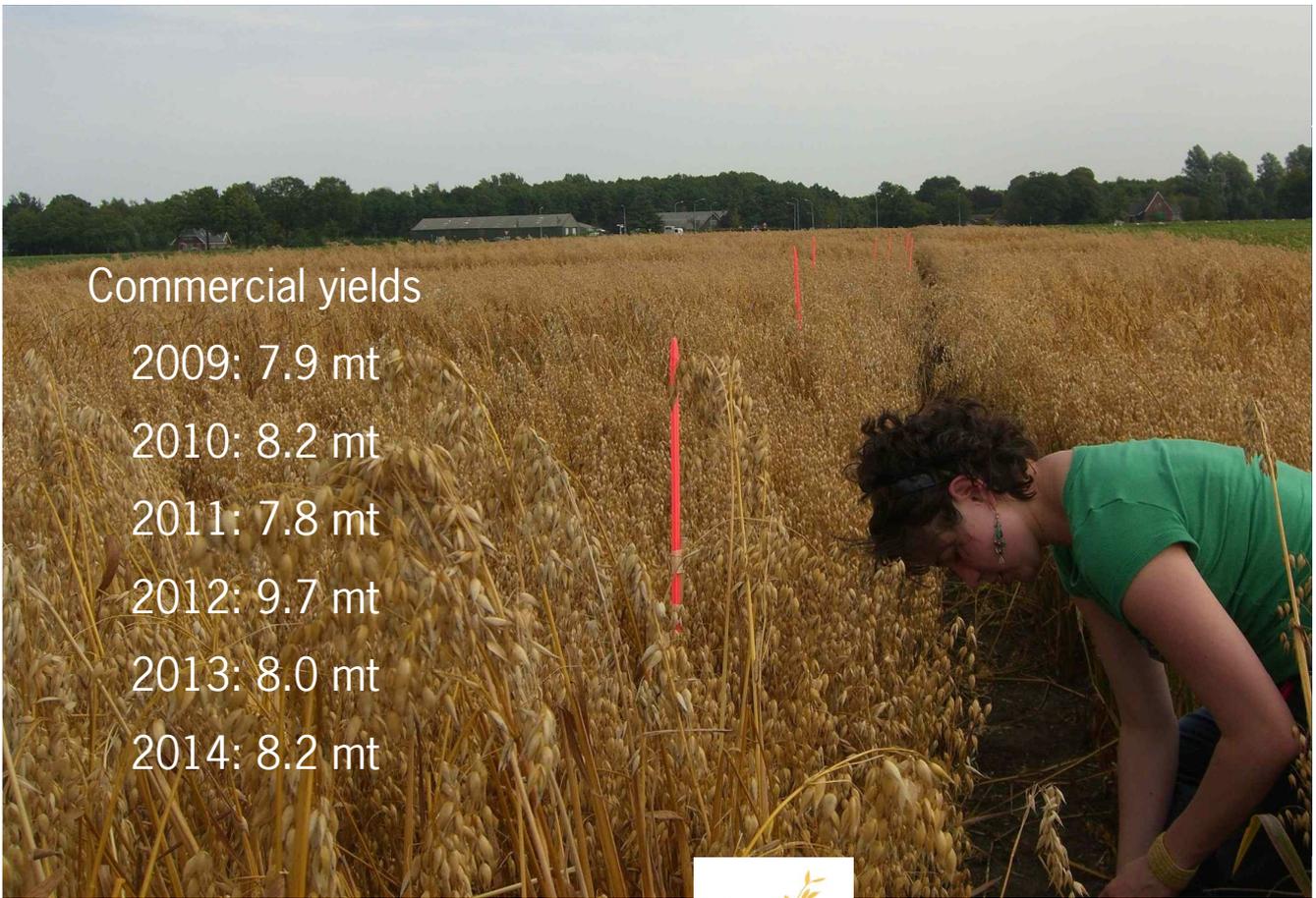
Oats in NL for CD

- Development of a safe (= contamination-free) and sustainable food production chain based on oats:



HACCP protocol

- Strict rules for gluten free oat cultivation
 - Farmer is certified for cultivation of cereals
 - No wheat, rye or barley has been grown on the parcel in five preceding years
 - Registration of the oat culture (location, variety, area [ha], yield, delivery)
 - Cultivation is at least once inspected on occurrence of wheat, barley, rye
 - Oat variety is in agreement with the customer
 - Sowing-seed is guaranteed free from contamination and is certified as such
 - Oat culture is sufficiently separated
 - Machines for sowing and harvesting are carefully cleaned
 - Delivered products to customer are fully traceable
 - Registration of complaints on the product – measures taken for improvement
 - Production of oat-based foods is only allowed in GF-certified companies



Commercial yields

- 2009: 7.9 mt
- 2010: 8.2 mt
- 2011: 7.8 mt
- 2012: 9.7 mt
- 2013: 8.0 mt
- 2014: 8.2 mt

EC Regulation 41/2009

- Allows oats to be labelled and sold as gluten-free provided a gluten contamination below 20 ppm
- Products on the market since 2011



Batter-based oat bread:
Mam's Havermixske from FreeOf



Dough-based oat bread (Londono et al., 2014)



Figure 1. Dough system (left) and baked loaf (right) made of pure oat flour.

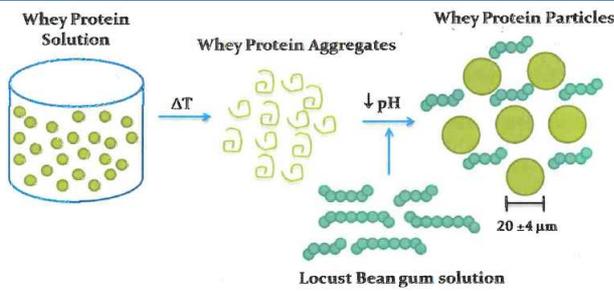


Figure 1. Scheme of the formation process of whey protein particles (WPP) (after Riemdsijk et al., 2011). In the first step, whey proteins form protein aggregates induced by heat (T). The second step consist of a self-aggregation process of the protein aggregates induced by a pH reduction in presence of a Locus bean gum solution. The final size of WPP is $20 \pm 4 \mu\text{m}$.

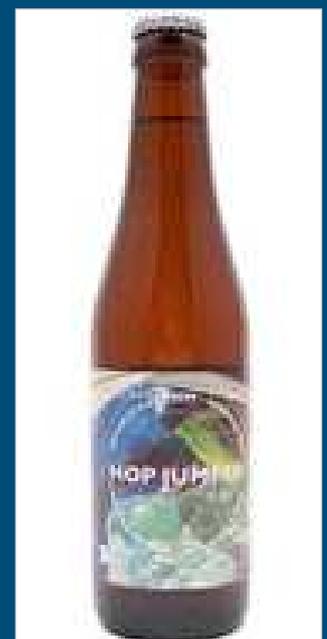
Haverbier

WATER HAVER HOP GIST

Experimenteel bier van hoge gisting met 100% Nederlandse brouwhaver, gemout en gebrouwen in Wageningen. < 10 ppm gluten

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The quality of life

Koyt beer (old Dutch beer style)



HOP JUMPER

AMERICAN HOPPED - DUTCH KOYT BEER

WITTE KLAVERVIER ZWOLLE THE NETHERLANDS
 INGREDIENTS: WATER, SOJAGRAIS, 25% BARLEY
 20% WHEAT, SILVER, TOORMALIJ, SMOOR HOPPS
 BEER BIER BIERE BIRRA CERVEZA ERBIS EBUSU
 STORE COOL & DARK DRINK RESPONSIBLY
 ALC. 4% VOL. 33CL. CALI BOTTLE 10 CT

8 717953 060969

BEST BEFORE: 3 6 9 12 2015 2016 2017 - A B C D

Conclusions on Oats

- Powerful, complete, versatile and healthy
- In field, feed and food
- Challenge to innovating (gluten free) bakery



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Thanks

- CDC consortium
 - Frits Koning
- Wageningen UR
 - Ingrid van der Meer
 - Rene Smulders
 - Hetty van den Broeck
 - Diana Londono
 - Elma Salentijn
 - Ed Hendrix
- Partners in 'De Nederlandse Haverketen'
- Micro-brewery Witte Klavervier
 - Freek Ruis



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