Structure of presentation:

1. Introduction to cereal fibre:
   - Dietary fibre (DF) definition;
   - Analytical methods & classification;
   - Cereal fibre and fibres isolated from cereal grains and plants;
   - Fibre contents in different grains & fractions;
   - Bioactive compounds associated with the fibre complex;
   - Fibre contents in different fractions and contribution of DF to Guidelines Daily Amounts (GDA)

2. Health challenges in Europe
   - Overweight; obesity; diabetes; cardiovascular disease; and colorectal cancer.

3. Health effects of cereal fibre
   - Cereal fibre and health- EU approved Health Claims;
   - Official recommendations;
   - Results from systematic reviews and meta-analyses;
   - Suggested mechanisms of action.
4. **Cereal fibre part of a balanced diet**
   - Different national recommendations for daily intake of cereal fibre;
   - How to increase the intake of cereal fibre? Chose WG foods insted of refined!

5. **Concluding remarks**
Cereal fibre consumption and potential impact on human health

- The role of cereal fibre in the prevention of lifestyle-related diseases such as obesity, cardiovascular diseases, diabetes and various types of cancer, has been a focal point in nutrition research.
- Cereal fibre consumption may have a beneficial impact on human health in different ways, i.e. weight management; cholesterol reduction; glycaemic control; bowel function; and gut brain/liver axis and immunostimulation). The scientific evidence is more evident for some intermediate and hard endpoints than for others.
- This presentation will focus on healthy weight, heart health, type 2 diabetes, colon cancer and their risk factors as well as life expectancy/mortality.
- A high cereal fibre intake is also related to other health effects (besides those mentioned in this slide) e.g. laxation.
Codex - Fibre Definition

A fibre definition is important for:

- Method development. Different definitions and methods give different results
- Food labelling and authorities (food composition tables and databases)
- Trade
- Research

To date there is no universal definition of fibre, however, the Codex Alimentarius Commission published in 2008 a working definition of dietary fibre. With Codex’ promotion of international harmonization for food labelling and food composition tables, it becomes easier to compare nutrition research and recommendations internationally.

Full text in CODEX definition on associated compounds:

“When derived from a plant origin, dietary fibre may include fractions of lignin and/or other compounds when associated with polysaccharides in the plant cell walls and if these compounds are quantified by the AOAC gravimetric analytical method for dietary fibre analysis: Fractions of lignin
and the other compounds (proteic fractions, phenolic compounds, waxes, saponins, phytates, cutin, phytosterols, etc.) intimately "associated" with plant polysaccharides are often extracted with the polysaccharides in the AOAC 991.43 method. These substances are included in the definition of fibre insofar as they are actually associated with the poly- or oligo-saccharidic fraction of fibre. However, when extracted or even re-introduced into a food containing non digestible polysaccharides, they cannot be defined as dietary fibre. When combined with polysaccharides, these associated substances may provide additional beneficial effects (pending adoption of Section on Methods of Analysis and Sampling)."

**Simple formulation of fibre definition:**

**Polysaccharides and oligosacharides with at least 3 sugar units** (Country specific decisions about whether Degree of Polymerisation 3-9 should be included or not). **Does not get absorbed at the small intestine.**

Fulfills either criteria:
- Carbohydrate polymers which **naturally exist** in foods (usually associated with other compounds),
- Carbohydrate polymers that **has been isolated** from food raw material and has a beneficial physiological effect
- **Synthetic polysaccharide** that has a beneficial physiological effect
- Components that are **non-carbohydrates**, but co-exist with carbohydrates in the cell walls.
Analysis of dietary fibre

• There are various analytical methods for the determination of dietary fibre:

  • The AOAC Official Methods 985.29 and 991.43 are most commonly used for analysis of "Total" Dietary Fibre (TDF). Method 991.43 also measures soluble and insoluble fibre. The great majority of data on amounts of fibre in products and in data on daily intake of fibre are based on analysis by these methods.

  • The new AOAC Official Method 2009.01 measures – separately - the high molecular weight fibre measured by methods 985.29 and 991.43 and, in addition to this, the low molecular weight fibres also included in the Codex definition.

• Several other new methods for certain components are currently under way.

  See annex slide for composition of HMWDF and LMWDF in different
products
Classification of fibres

The Codex fibre definition differentiates between:

- Fibres *naturally occurring in the food* as consumed

  AND

- *Isolated and synthesised fibre*

For fibres naturally occurring in food, the health benefits are generally accepted, but these also contain - beyond fibre - a range of co-passengers (such as lignans and alkylresorcinols)\(^1\) that exert health impacts in the human diet. Isolated and synthesised fibres, often contain no co-passengers, and the inclusion of their health benefits requires acceptance by authorities.

Fibres naturally occurring in foods includes cereal fibres
- In any grain, flour and products made with these grains and flours
- In fibre-rich fractions of grains, such as bran and aleurone where co-passengers are not removed

Wheat bran and wheat aleurone are sold as commercial products, as is
also the case with beta-glucan rich oat fractions, obtained by removing starch from oat flour.

Isolated fibres - Examples
- Resistant wheat maltodextrin
- Resistant maize maltodextrin
- Resistant starch
- Cellulosic fibre from wheat straw

Commercially available as
- Nutriose
- Fibersol
- Hi-Maize
- Vitacel

Synthesised fibres – Examples
- Hydroxypropyl methylcellulose
- Methocel
- Several chemically modified starches

Dietary- and cereal fibre

- Dietary fibres are found in whole grains. The relative contribution of naturally occurring cereal fibre to the fractions of the grain varies (indicated by the size of the arrows) and so does the contribution among grains. Detailed information about the relative contributions in various grains is presented in slide 7.

- Observational studies and the related intake of dietary fibre are referring to the 1st category of fibre in the Codex definition: "Edible carbohydrate polymers naturally occurring in the food as consumed". Many studies also consider differences in health effects of fibres from fruits, vegetables and (whole) grains.

- Studies on isolated or synthetic fibres usually discuss technological performance of these fibres and/or effects on health, the latter based on intervention studies with animals or humans.

- Isolated fibres are usually labelled on ingredient lists with their generic name (e.g. ‘resistant starch’). However, cellulosic fibres from straw are often labelled as ‘wheat fibre’ or ‘oat fibre’.

- In order to avoid confusion, the Healthgrain Forum recommends such fibres being labelled as: ‘cellulosic fibre from wheat’ (or oats)

1 Jones, J., *Dietary Fibre – New Frontiers for Food and Health*, 368
Dietary fibre has been classified in a number of ways. Typically dietary fibre has been divided into **soluble (SDF)** and **insoluble fibre (IDF)**. Based on water solubility, this classification system proved very useful in the initial understanding of the physiological properties of dietary fibre, allowing a simple division into those which principally had effects on glucose and lipid absorption from the small intestine (soluble) and those which were slowly and incompletely fermented and had more pronounced effects on bowel habit (insoluble)^1\).

**Fermentable and non-fermentable dietary fibre** is a more recent classification system which separates dietary fiber based on whether it can be fermented by the microbiota in the large intestine (http://www.foodincanada.com/features/fibre-measurement). In its FAO Food and Nutrition Paper (1998), the FAO recommended the gradual phasing out of the terms.
soluble and insoluble dietary fibre but rather using the terms fermentable and non-fermentable dietary fibre².

The AOAC method 2009.01 allows the accurate measurement of insoluble dietary fibre; high molecular weight soluble dietary fibre (HMWSDF); and low molecular weight soluble dietary fibre (LMWSDF)³. When fibre is analysed by the AOAC method 2009.01 – or by a similar, recently developed new method – the Healthgrain Forum recommends to report not only TDF (total dietary fibre) but also the measured levels of HMW (High Molecular Weight) and LMW (Low Molecular Weight) fibre. HMW measured with 2009.01 usually corresponds well with TDF measured with the classical AOAC methods.

² FAO, http://www.fao.org/docrep/w8079e/w8079e0c.htm#chapter%206%20%20recommendations.
³ Delcour et Poutanen (ed.) 2013, *Fibre-rich and Wholegrain Foods*, p.33
Fibre in cereals and location of bioactive compounds

The grain kernel is composed of starchy endosperm, germ and bran.

- **Bran** is a technological fraction and includes: aleurone, testa and pericarp.
  - Aleurone belongs to the endosperm from a botanical point of view.
  - While the contribution of cereal fibre to the three components differ, so does the relative contribution of cereal fibre to the various cereal types. Barley, rye, wheat and oats are the four cereal types that contain the highest amounts of cereal fibre. Values are according to measurement with classical methods (AOAC 985.29 or AOAC 991.43). This means that fructans and oligosaccharides are not included and for examples DF values in rye will be considerably higher with recent methods such as AOAC2009.01.

Wide physiological definition of dietary fibre which includes many different types of components:
• Cell wall polysaccharides, e.g. cellulose, arabinofuranose
• Storage polysaccharides, except starch, e.g. fructan and beta-glucan
• Resistant oligosaccharides, e.g. fructo-oligosaccharides
• Lignin and other associated components which are not carbohydrates
• Resistant starch
Fibre content in different cereal fractions

- The composition and content of dietary fibre varies considerably between grains and also between fractions within grains.
- While barley, rye, oats, wheat and buckwheat have high dietary fibre contents, the dietary fibre content in rice is lowest.
- Wheat bran is rich in total fibre, mainly insoluble arabinoxylans.
- Oats and barley are rich in soluble beta-glucans which may have cholesterol reduction properties (when molecular weight is large enough to generate viscosity).
Free and bound phytochemicals associated with fibre

There are several groups of bioactive compounds in cereal grains. One main group is **phenolic compounds** which can further be divided into the following classes:

- Hydroxycinnamic acids (e.g. ferulic, sinapic and p-coumaric acids)
- Hydroxybenzoic acids (e.g. gallic, vanillic, syringic acids)
- Flavonoids (mainly anthocyanidins and condensed tannins are also present in cereals. Large variation between grains)
- Avenanthramides (only in oats)

In cereals, **phenolic compounds are typically present in free or bound form**:

1) free compounds (measurable in extracts, mainly found in outer pericarp)
2) esterified compounds (released with basic or acidic hydrolysis)
3) insoluble compounds (remaining after extraction and hydrolysis)
Free compounds are taken up to by various degrees and absorbed (bound?) phenolic compounds are typically eliminated fast.

Bound compounds will be released once they reach the large intestine where gut microflora will liberate them. Liberated compounds may have positive effects locally in the large intestine or once they get absorbed. Some of these compounds have strong antioxidative effects.
Differences in the contribution of fibre from grain fractions to Guidelines Daily Amounts (GDA)

The data in the bars show how much the consumption of 100g of different cereal fractions accounts for in comparison to the GDA for fibre\(^1\).

For fibre, 25g fibre per day is the amount defined by EFSA as adequate for normal laxation in adults.

EFSA mentions that there is evidence in adults of benefit to health associated with consumption of diets rich in fibre-containing foods at dietary fibre intakes greater than 25g/day, e.g. reduced risk of coronary heart disease and type 2 diabetes and weight maintenance\(^2\).

For instance, the consumption of 100g whole grain wheat flour accounts for 42.8% of GDA on fibre whereas 100g refined wheat flour accounts for 10.8% of GDA on fibre.

Note: upon processing flour with water and heat (e.g. baking, extrusion) some starch is converted to fibre (resistant starch)

\(^1\) EFSA Scientific Opinion of the Panel on Dietetic Products, Nutrition and
Allergies, EFSA Journal (2009) 1008, 1-14

2 EFSA Scientific Opinion on Dietary Reference Values for Carbohydrates and Dietary Fibre, EFSA Journal (2010); 8(3):1462
Overweight – a growing European problem

The next set of slides will show a summary of the current situation regarding non-communicable diseases in Europe.

Overweight

• On average, overweight affects between 25-80% of adults in the EU
• In Ireland, more than 80% of all males are overweight
• In Germany, 75% of the male population
• Approximately 20% of all EU children and adolescents are overweight and a third of these are obese (*Fact sheet 5 - Childhood obesity surveillance in the WHO European Region*).
Obesity

- Obesity affects 10-30% of adults in the EU
- 31% of all males in Ireland are obese
- 23.89% of all males in the Czech Republic are obese
- 22.3% of all males in the UK are obese
- In addition to causing various physical disabilities and psychological problems, excess weight drastically increases a person’s risk of developing a number of non-communicable diseases (NCDs), including cardiovascular disease, cancer and diabetes. The risk of developing more than one of these diseases (co-morbidity) also increases with increasing body weight\(^1\).

The results of studies on health benefits of cereal fibre presented in this and subsequent slides are being used widely for dietary recommendations. However, more research is needed for elucidation of mechanisms contributing to risk reduction and for obtaining more information on physiological effects of different types of dietary fibre, associated compounds and how they are affected by food processing.

\(^1\) WHO-Obesity, European Region
Diabetes

• In 2013 there are no EU countries in the upper red category.

• In 2035 it is estimated that the prevalence of diabetes in Portugal will have arisen to more than 15% of the national population.

• In 2035 the national prevalence of diabetes in Cyprus (12,5%), Slovenia (12,5%), Slovakia (13,9%) and Germany (14,1%) is estimated to lie between 12-15% of the population.

Source: http://www.idf.org/diabetesatlas/data-downloads
CVD

- CVD is the main cause of death for women in Europe, and the main cause of death for men too in Europe (except for 6 countries)

- CVD mortality is falling in most countries
The main cause of death in the EU is Cardiovascular disease (CVD)

Death by cause, MEN

- Coronary heart disease (CHD) and stroke are the main forms of CVD
- CVD causes 47% of all deaths in Europe and 40% in EU
Colorectal cancer

- CRC is the second most common cancer form (13% of total cancers) in both men and women (more common for men).

Figures for cancer overall:
- There were just over 3.4 million new cases of cancer (excluding non-melanoma skin cancers) in Europe in 2012, 53% (1.8 million) occurring in men and 47% (1.6 million) in women.

- The most common cancer sites were breast cancer (464,000 cases, 13.5% of all cancer cases), followed by colorectal cancer (447,000, 13.0%), prostate cancer (417,000, 12.1%) and lung cancer (410,000, 11.9%). These four cancers represented half (50.5%) of the estimated overall burden of cancer in Europe in 2012.

- The estimated total number of cancer deaths in Europe in 2012 was 1.75 million, of which 56% (976,000) were in men and 44% (779,000) in women.

Colorectal cancer the second most frequent cause of death from cancer
in Europe in 2012 (almost 215,000 deaths, 12.2%).

Health effects of cereal fibre

The current status on cereal fibre and health effects in the next slides are based on:

1) EU approved health claims
2) Official recommendations by Nutritional Societies
3) Results from systematic reviews and meta-analyses

Focus has been put on cereal fibre and Type 2 Diabetes (T2D), Cardiovascular diseases (CVD) and colorectal cancer (CRC) as well as some of their risk factors.

*It is important to remember that results from epidemiological studies where cereal fibre has been investigated in relation to hard endpoints may not reflect causal relationships. There is always a risk of confounding in such studies. There is currently a lack of long-term randomized controlled trails.*
Nutrition claims for fibre

Full text in Text in Regulation (EC) No 1924/2006 on nutrition and health claims made on foods

SOURCE OF FIBRE
A claim that a food is a source of fibre, and any claim likely to have the same meaning for the consumer, may only be made where the product contains at least 3 g of fibre per 100 g or at least 1.5 g of fibre per 100 kcal.

HIGH FIBRE
A claim that a food is high in fibre, and any claim likely to have the same meaning for the consumer, may only be made where the product contains at least 6 g of fibre per 100 g or at least 3 g of fibre per 100 (kcal).

Codex recommendations include as additional text
- Conditions for nutrient content claims in liquid foods to be determined at national level.
Serving size and daily reference value to be determined at national level.

In the USA 3 and 6 g fibre per serving of a product is required for being a Source of and High fibre, respectively. Serving sizes are often much lower than 100g. high fibre levels are required – example:
- For bread (serving size of 28.5g, 1 Oz) 10.5g fibre / 100g is required for 'Source of fibre'
EU authorised health claims on cereal fibre – laxation

CLAIMS ON BOWEL FUNCTION

EFSA (2010a) considers a fibre intake of 25 g/day to be adequate for normal laxation in adults.

The EFSA Panel notes that there is evidence in adults of benefit to health associated with consumption of diets rich in fibre-containing foods at dietary fibre intakes greater than 25 g per day, for example reduced risk of coronary heart disease and type 2 diabetes and improved weight maintenance.

Comment in report 2011;9(6):2249 on oat and barley grain fibre:
- the role of cereal grain fibre in increasing faecal bulk in humans is well established,
- the mechanisms by which cereal grain fibre exerts the claimed effect are known,
- oat fibre has a significant bulking effect, a similar effect can be expected from barley grain fibre

Comment in report 2010;8(10):1817 on wheat bran fibre
“Wheat grain fibre”, “wheat bran and wheat bran products”, and “Triticum aestivum – wheat bran”. The Panel assumes that the active food constituent is wheat bran fibre.
**EU authorised Health Claims on Cereal Fibre and Cholesterol levels**

<table>
<thead>
<tr>
<th>Material</th>
<th>Health claim</th>
<th>Conditions of use</th>
<th>EFSA opinion reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>β-glucans (Bg)</td>
<td>Maintenance of normal cholesterol levels (Article 13.1 claim)</td>
<td>Daily intake of 3 g required, Food with ≥ 1 g of Bg per quantified portion.</td>
<td>2009.7(9):1254, 2011.9(6):2207</td>
</tr>
<tr>
<td>Oat β-glucan</td>
<td>Oat (respectively barley) beta-glucan has been shown to lower/reduce blood cholesterol. High cholesterol is a risk factor in the development of coronary heart disease Article 14.(1)(a) claim (disease reduction claim)</td>
<td>Daily intake of 3 g required, Foods which provide at least 1g of oat (respectively barley) per portion</td>
<td>Q-2008-681, Q-2011-00798 and Q-2011-0079</td>
</tr>
<tr>
<td>Barley β-glucan</td>
<td></td>
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</tr>
</tbody>
</table>

**EU authorised Health Claims on Cereal Fibre and Cholesterol levels**

The EFSA Panel notes that there is evidence in adults of benefit to health associated with consumption of diets rich in fibre-containing foods at dietary fibre intakes greater than 25 g per day, for example reduced risk of coronary heart disease and type 2 diabetes and improved weight maintenance.

**EFSA approved a number of health claims for specific, well characterised fibres but rejected many others:**

- Health claims for total and soluble dietary fibre – due to insufficient characterisation of the material;
- All health claims covering pre- and probiotic effects;
- Many health claims for fibres obtained by isolation and further processing of fibres, including claims for wheat-based resistant maltodextrins and for inulins;
- No health claims were submitted for a range of isolated fibres, including cellulosic fibres from wheat straw and arabinoylan oligosaccharides

*Note: in addition to the Article 13.1 ‘General function’ claims, authorised for a range of cereal fibres, for β-glucan of oats and barley also Article*
14(1)(a) ‘Disease reduction’ claims were authorised
EU authorised Health Claims on Cereal Fibre and reduced glucose rise after a meal

Health claims on the reduction of post-prandial blood glucose responses are supported by EFSA under the following conditions:

- **8g arabinoxylan (AX)-rich fibre produced from wheat endosperm** (at least 60% AX of total CHO by weight) for individuals who wish to reduce their postprandial glycaemic responses. The following wording is suggested: “Consumption of arabinoxylan contributes to a reduction of the glucose rise after a meal”.

- **4 g Oats or barley beta-glucans per 30 g CHO.** The following wording is suggested:“Consumption of beta-glucans from oats or barley contributes to the reduction of the glucose rise after a meal” (2011)

- **However**, cause and effects for beta-glucans and long-term effects have not been established.  

- **Replacing digestible starch with resistant starch from all sources;** at least 14% of total starch should be resistant starch in replacement to digestible starch. The following wording has been suggested: “Replacing digestible starch with resistant starch induces a lower blood glucose rise after a meal.”

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**EU authorised Health Claims on Cereal Fibre and reduced glucose rise after a meal**

<table>
<thead>
<tr>
<th>Material</th>
<th>Health claim</th>
<th>Conditions of use</th>
<th>EFSA Opinion Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arabinoxylan produced from wheat endosperm</td>
<td>Reduction of blood glucose rise after a meal</td>
<td>Daily intake ≥ 8g AX rich fibre</td>
<td>2011:9(6):2205</td>
</tr>
<tr>
<td>β-glucans from oats and barley</td>
<td>Intake ≥ 4g / 30g digestible carbs</td>
<td></td>
<td>2011:9(6):2207</td>
</tr>
<tr>
<td>Resistant starch (RS)</td>
<td>RS Content ≥ 14% of total starch</td>
<td></td>
<td>2011:9(4):2024</td>
</tr>
</tbody>
</table>
1 EFSA Journal 2010;8(2):1482.
Scientific Statements of Cereal Fibre and Disease

Cho et al:
“Most whole-grain studies included mixtures of whole grains and foods with ≥25% bran. Prospective studies consistently showed a reduced risk of Type 2 Diabetes with high intakes of cereal fibre or mixtures of whole grains and bran. For body weight, a limited number of prospective studies on cereal fibre and whole grains reported small but significant reductions in weight gain. For CVD, studies found reduced risk with high intakes of cereal fibre or mixtures of whole grains and bran.”

Summary of evidence level (according to similar system as American Diabetes Association\(^1\))

<table>
<thead>
<tr>
<th>Hypertension</th>
<th>T2D</th>
<th>Obesity</th>
<th>CVD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cereal fibre</td>
<td>D</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>Mixtures of whole grains and bran</td>
<td>D</td>
<td>B</td>
<td>B</td>
</tr>
</tbody>
</table>
* In the 2010 Dietary Guidelines for Americans (DGA), whole grain, but not other sources was mentioned as a source of dietary fibre.

1 Clinical practice recommendation. *Diabetes Care* 2012;35(suppl 1):S1–2
German Nutrition Society - Cereal Fibre and Disease

Main findings by Hauner et al.:

• “The prospective cohort studies indicate with high consistency that high intake of whole-grain products or dietary fibre from cereal products, respectively, causes a lower risk of diabetes. The evidence regarding this association is judged as probable”.

• According to a Cochrane review including 10 controlled intervention studies with a duration of 4-8 weeks, the consumption of whole grain products (8 of them oat-meal based) resulted in significant decrease in the plasma total cholesterol concentration compared with the control diet. The plasma concentration of LDL cholesterol, too, was significantly lower at the end of the studies than the baseline.1

In conclusion:

• „With probable evidence, high total dietary fibre intake lowers the risk of obesity in adults, as well as of hypertension and CHD. There is possible evidence that a high total dietary fibre intake lowers the risk of dyslipoproteinaemia (by lowering total and LDL cholesterol concentrations) and of colorectal cancer. High intake of dietary fibre from cereal products lowers the risk of type 2 diabetes mellitus and of
colorectal cancer with probable evidence; the risk of CHD and stomach cancer is lowered with possible evidence. If only whole grain products are considered, there is probable evidence that a high intake reduces the risk of type 2 diabetes mellitus, hypertension and CHD. A high intake of whole-grain products lowers the concentrations of total and LDL cholesterol with convincing evidence².

- The scientific evidence for overweight/obesity is less strong compared to CVD and diabetes type 2. Here more research is needed.

¹ Hauner et al., p.29
² Hauner et al., p.49
# German Nutrition Society – Summary of Evidence

<table>
<thead>
<tr>
<th></th>
<th>T2D</th>
<th>CHD</th>
<th>Stomach cancer</th>
<th>Colon cancer</th>
<th>Obesity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total dietary fibre (DF)</td>
<td>O</td>
<td>↓</td>
<td>~</td>
<td>↓</td>
<td>↓↓</td>
</tr>
<tr>
<td>DF from cereal products</td>
<td>↓↓</td>
<td>↓</td>
<td>↓</td>
<td>↓↓</td>
<td>~</td>
</tr>
<tr>
<td>Wholegrain products</td>
<td>↓↓</td>
<td>↓</td>
<td>–</td>
<td>–</td>
<td>↓</td>
</tr>
</tbody>
</table>

**Legend**
- ~ not assessed
- O possible evidence, no association
- ↓ possible evidence, risk reducing
- ↓↓ probable evidence, risk reducing
- ~ insufficient evidence

Whole grain, dietary fibre, and disease – review

• Similar results as shown in the ASN and the German summary shown on the previous slides

• Whole grain foods, not cereal fibre, was shown to have beneficial effects on intermediate end points too.

<table>
<thead>
<tr>
<th>Metabolic biomarkers</th>
<th>Studies, n</th>
<th>Weighted mean difference (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fasting insulin, pmol/L</td>
<td>10</td>
<td>−0.29 (−0.59, 0.01)</td>
</tr>
<tr>
<td>Fasting glucose, mmol/L</td>
<td>11</td>
<td>−0.93 (−1.65, −0.21)</td>
</tr>
<tr>
<td>Total cholesterol, mmol/L</td>
<td>16</td>
<td>−0.83 (−1.24, −0.42)</td>
</tr>
<tr>
<td>LDL-cholesterol, mmol/L</td>
<td>15</td>
<td>−0.72 (−1.34, −0.11)</td>
</tr>
<tr>
<td>Systolic blood pressure, mm Hg</td>
<td>6</td>
<td>−0.21 (−0.54, 0.18)</td>
</tr>
<tr>
<td>Diastolic blood pressure, mm Hg</td>
<td>6</td>
<td>−0.05 (−0.21, 0.11)</td>
</tr>
</tbody>
</table>
Dietary Fibre and CVD

Summary by the authors:

• Diets high in fibre—specifically from cereal or vegetable sources and rich in insoluble type fibre—are significantly associated with lower risk of CHD and CVD and reflect recommendations to increase intake.

• Greater intake of fruit fibre was also associated with lower CVD risk. These data provide evidence relating to whole food consumption and therefore do not support consumption of foods specifically enriched in cereal or vegetable derived fibre.

• Evidence relating to soluble or insoluble types of fibre was more limited and further investigation in this area would be of use. A limited evidence base also exists from countries outside the US, Europe, Japan, or Australia.
Cereal fibre and stroke- more data needed

This is the first meta-analysis on fibre, fibre sources and stroke.

- Eight cohort studies from the United States, northern Europe, Australia, and Japan met inclusion criteria.
- Total dietary fibre intake was inversely associated with risk of hemorrhagic plus ischemic stroke, with some evidence of heterogeneity between studies (I(2); relative risk per 7 g/day, 0.93; 95% confidence interval, 0.88-0.98; I(2)=59%).
- Soluble fibre intake, per 4 g/day, was not associated with stroke risk reduction with evidence of low heterogeneity between studies, relative risk 0.94 (95% confidence interval, 0.88-1.01; I(2)=21%).
- There were few studies reporting stroke risk in relation to insoluble fibre or fibre source
DF and colorectal cancer- cereal fibre appears more effective than other fibres

Systematic review by Aune et al:

- Seven studies were included in the study of total whole grain (including whole grain rye breads, whole grain breads, oatmeal, whole grain cereals, high fibre cereals, brown rice, and porridge) intake and risk of colorectal cancer.

- Systematic review and meta-analysis of prospective observational studies suggest:
  - 10% reduction in risk of colorectal cancer for each 10g/day intake of total dietary fibre and cereal fibre.

EPIC study:

- After a mean follow-up of 11.0 years, 4,517 incident cases of colorectal cancer were documented. Total, cereal, fruit, and vegetable fibre intakes were estimated from dietary questionnaires at baseline.

- Hazard ratios (HRs) and 95% confidence intervals (CIs) were estimated using Cox proportional hazards models stratified by age, sex, and centre, and adjusted for total energy intake, body mass index, physical activity, smoking, education, menopausal status, hormone replacement
therapy, oral contraceptive use, and intakes of alcohol, folate, red and processed meats, and calcium.

- After multivariable adjustments, total dietary fibre was inversely associated with colorectal cancer (HR per 10 g/day increase in fibre 0.87, 95% CI: 0.79–0.96). Similar linear associations were observed for colon and rectal cancers. The association between total dietary fibre and risk of colorectal cancer risk did not differ by age, sex, or anthropometric, lifestyle, and dietary variables.
- Fibre from cereals and fibre from fruit and vegetables were similarly associated with colon cancer; but for rectal cancer, the inverse association was only evident for fibre from cereals.
- Conclusions/Significance stated by the authors: “Our results strengthen the evidence for the role of high dietary fibre intake in colorectal cancer prevention”.

Dietary fibre and Breast Cancer

In this systematic review and meta-analysis of prospective studies, there was an inverse association between dietary fibre intake and breast cancer risk.

- Evidence from case-control studies have suggested that dietary fibre may be inversely related to breast cancer risk, but it is unclear if this is supported by prospective data.
- PubMed was searched for prospective studies of fibre intake and breast cancer risk until 31st August 2011. Random effects models were used to estimate summary relative risks (RRs).
- Sixteen prospective studies were included.
- RR for the highest vs lowest intake was 0.93 [95% confidence interval (CI) 0.89-0.98, I(2) = 0%] for dietary fibre,
  0.95 (95% CI 0.86-1.06, I(2) = 4%) for fruit fibre,
  0.99 (95% CI 0.92-1.07, I(2) = 1%) for vegetable fibre,
  **0.96 (95% CI 0.90-1.02, I(2) = 5%) for cereal fibre**,  
  0.91 (95% CI 0.84-0.99, I(2) = 7%) for soluble fibre
  0.95 (95% CI 0.89-1.02, I(2) = 0%) for insoluble fibre.
• The summary RR per 10 g/day of dietary fibre was 0.95 (95% CI 0.91-0.98, I(2) = 0%, P(heterogeneity) = 0.82).

• In stratified analyses, the inverse association was only observed among studies with a large range (≥13 g/day) or high level of intake (≥25 g/day).
Fibre from different sources and mortality in Europeans

Conclusions from this study:

• **Higher fibre intake is associated with lower mortality**, particularly from circulatory, digestive, and non-CVD non-cancer inflammatory diseases. Our results support current recommendations of high dietary fibre intake for health maintenance.

• During a mean follow-up of 12.7 y, a total of 23,582 deaths were recorded.
  - Fibre intake was inversely associated with:
    - total mortality: HR (per 10-g/d increase): 0.90; 95% CI: 0.88, 0.92;
    - mortality from circulatory diseases: HR (per 10-g/d increase): 0.90 and 0.88 (men, woman)
    - mortality from digestive diseases: HR: 0.61 and 0.64 (women, men)
    - mortality from respiratory diseases: HR: 0.77 and 0.62 (woman, men)
    - mortality from non-CVD non-cancer inflammatory diseases: HR: 0.85 and 0.80 (woman, men)

- smoking-related cancers: HR: 0.86 and 0.89 (woman, men)
  No association with non-smoking-related cancers (HR: 1.05 and 0.97).

- The associations were more evident for fibre from cereals and vegetables than from fruit.
- The associations were similar across BMI and physical activity categories but were stronger in smokers and participants who consumed >18 g alcohol/d.
Cummings (1993) evaluated nearly 100 interventions, published from 1932 to 1984, on dietary fibre and faecal weight, and compared the effectiveness of different sources of fibre.

Among 41 interventions that examined wheat fibre—which consisted largely of wheat bran—the mean increase in faecal weight per g/d of wheat fibre was 5.4 g.

The mean increases in faecal weight per g/d of other sources of fibre were smaller in magnitude: fruit and vegetables (4.7 g), gums and mucilages (3.7 g), cellulose (3.5 g), oats (3.4 g), corn (3.3 g), legumes (2.2 g), and pectin (1.2 g).
Cereal fibre and weight management- results from observational studies and RCTs

Obervational studies:

Randomized controlled trails:

Whole grain consumption does not decrease body weight compared with control, but small beneficial effect on body fat may be present (Pol et al. (2013) Am J Clin Nutr.)

Mckeown et al (J Nutr; 2009;139(10):1950-5) examined the associations among grain intake (whole and refined), dietary fibre and fibre sources, and body fat among older adults.

- Data from 434 free-living adults (177 men and 257 women) aged between 60 and 80 y. Dietary intake was estimated from a 126-item semi-quantitative FFQ. Percent body fat and percent trunk fat mass were measured by whole-body DEXA.

- Cereal fibre was inversely associated with:
  - BMI [27.3 kg/m(2) (26.1-28.6) vs. 25.4 kg/m(2) (24.3-26.7); P-trend = 0.012],
  - percent body fat [34.7% (32.8-36.6) vs. 31.5% (29.4-33.5); P-trend = 0.004]
  - percent trunk fat mass [42.8% (40.2-45.4) vs. 37.8% (35.0-40.6); P-trend = 0.001].
• No significant association was observed between intakes of total fibre, vegetable or fruit fibre, and body composition measurements.

• **Author’s conclusions:** Higher intakes of cereal fibre, particularly from whole-grain sources, are associated with lower total percent body fat and percent trunk fat mass in older adults.
Health effects of dietary fibre – suggested mechanisms

Some frequently suggested mechanisms for the health benefits of cereal fibre are shown here but many more exist.

Note: Health effects of cereal fibre are also influenced by processing conditions.

Two examples:
- Water absorption capacity of wheat bran – and its associated beneficial effect on laxation – increases with increasing particle size, which may be realised by less fine milling.
- Cholesterol reducing effects by beta-glucans is dependent on molecular weight. Processing may lead to degradation of beta-glucan and its beneficial effects.

For approval of health claims, EFSA usually does not take into account such effects introduced by processing.

Note! GI: Glycaemic Index
IL: Insulin
Hot research topics on cereal fibre

Cereal fibre and effects on:

- **Immune system**
  - Role of prebiotics in inflammatory bowel disease (J Biol Regul Homeost Agents 2013;27(4):919-33.)

- **Mental function**
  - Effects on memory (episodic, semantic, and working memory), language, attention, executive function, and information processing speed (Nutr Rev. 2014 Mar;72(3):162-70)

- **"Gut-brain &/or- liver" axis**
  - Influence of the microbial-mammalian metabolic axis with implication for energy metabolism, appetite and cognitive functions. Effects of cereal fibre fermentation products such as SCFA on host health

Recommended dietary fibre consumption across the world

<table>
<thead>
<tr>
<th>Intake/day</th>
<th>Remarks</th>
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<tbody>
<tr>
<td>EFSA (2010)</td>
<td>25 g is adequate for normal laxation in adults. Diets rich in fibre containing foods at DF intakes ≥ 25g are associated with additional health benefits</td>
</tr>
<tr>
<td>WHO (2003)</td>
<td>≥ 25g Total dietary fibre from whole grain cereals, fruit and vegetables</td>
</tr>
<tr>
<td>Germany, Austria, Switzerland (D-A-CH, 2008)</td>
<td>≥ 30g At least 30 grams of dietary fibre daily, especially from whole-grain products</td>
</tr>
<tr>
<td>Netherlands (GR, 2001, 2006)</td>
<td>30-40g 30-40 g dietary fibre via products not enriched with isolated and purified dietary fibre</td>
</tr>
<tr>
<td>Nordic Countries (NFR 2012)</td>
<td>25-35g</td>
</tr>
<tr>
<td>USA (IoM, 2005)</td>
<td>25-38g Total fibre from whole grain cereals, fruit and vegetables for women and men, respectively</td>
</tr>
<tr>
<td>USA (USDA, 2010)</td>
<td>Consuming enough whole grains helps meet nutrient needs. Choosing whole grains that are higher in dietary fibre has additional health benefits</td>
</tr>
<tr>
<td>UK (DoH, 1991)</td>
<td>18 g (NSP) 18 g non-starch polysaccharides</td>
</tr>
</tbody>
</table>

The national recommendations as presented here are based on a 2000 kcal diet which is the approved EU guideline for the average population.

• Whole grain is the preferred way for fibre intake (Germany).
• Similarly, in the Netherlands, a high whole grain bread consumption is recommended based on the official policy of high fibre intake from grains, fruits and vegetables.

The EFSA recommendation is related to normal laxation in adults. Regarding (national) dietary guidelines EFSA suggests to consider higher recommended intakes:

*The Panel notes that there is evidence in adults of benefit to health associated with consumption of diets rich in fibre-containing foods at*
dietary fibre intakes greater than 25 g per day, e.g. reduced risk of coronary heart disease and type 2 diabetes and improved weight maintenance. Such evidence should be considered when developing food-based dietary guidelines.

Concluding remarks

- Dietary fibre is defined world-wide
- Whole grains, especially from wheat, rye, oats and barley, and bran products are good sources of dietary fibre (cereal fibre)
- High cereal fibre intake is associated with a reduced risk of obesity, T2D, CVD and colorectal cancer
- β-glucans (>3g/d) from oats and barley reduce cholesterol and improves glycaemic response after a meal (>4g per 30g CHO)
- Among the dietary fibre sources, cereal fibre show stronger beneficial associations with non-communicable diseases
- Many different mechanisms have been suggested for attributing protective effects to properties of fibre such as solubility, viscosity, fermentability and associated bioactive compounds.
The HEALTHGRAIN EU Integrated Project (2005-2010) - the largest cereal project ever – has substantially strengthened the scientific basis for a new generation of cereal products with enhanced health benefits.

The Healthgrain Forum (www.healthgrain.org) has been initiated in 2010 for continuing HEALTHGRAIN’s research, networking and communication activities. Currently (status October 2014) 54 member organisations joined, with an even balance between academia, research organisations, industry and members focusing on communication on grains and health.

The Healthgrain Forum will evaluate and update this presentation annually. For questions and suggestions please contact:

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ANNEX

Content
- Fibre analysis – comparison of old and new AOAC Methods
- EU Health Claims on Fibre and Cereal Fibre
Note! please note that there is a summary mistake in table 2: the total fibre of HMWDF = 5.2 and LMWDF = 1.1 does not summarize to 5.3 (which is indicated in the table), but to 6.3.
Based on scientific assessment by EFSA
- the EU authorised a number of health claims for specific, well characterised fibres
  authorised claims for cereal fibres are presented in the next slides
- the EU did not authorise many other submitted claims, such as
  - Health claims for total and soluble dietary fibre – due to insufficient characterisation of the material;
  - All health claims covering pre- and probiotic effects;
  - Many health claims for fibres obtained by isolation and further processing of fibres, including claims for wheat- based resistant maltodextrins and for inulins, due to insufficient evidence
No health claims were submitted for a range of isolated fibres, including cellulosic fibres from wheat straw and arabinoxylan oligosaccharides

The EU approved a definition of dietary fibre and EFSA (2010) made a recommendation for daily intake of dietary fibre (shown later in the overview of dietary recommendations). However, for approval of health claims EFSA applied more rigorous criteria.