Grain Products: Short and long-term benefits for health and wellbeing

Report from the Healthgrain Forum Session at the 12th European Nutrition Congress FENS 2015 on 20th October 2015, Berlin, Germany


Dr Margaret Ashwell OBE, FAfN, Ashwell Associates, President of the Association for Nutrition; Honorary Senior Visiting Fellow Cass Business School, UK, and **Dr Jan-Willem van der Kamp**, Senior Advisor, TNO Food and Nutrition, Zeist, The Netherlands

Whole grain and cereal fibre consumption is associated with a lower risk of major chronic non communicable diseases (e.g. type 2 diabetes, CVD, cancer) and lower overall mortality. Although the epidemiological evidence is convincing, we still need more evidence from long-term intervention trials.

In addition to the well-established laxative benefits of cereal fibre, recent studies also show short-term benefits for psychological wellbeing. Wholegrain fractions with prebiotic properties, appear to be potentially important modulators of the gut microbiota with positive consequences on host health. They may also improve obesity-related metabolic disorders, including insulin resistance.

Increased consumption of whole grain foods should be recommended to the general population, irrespective of age, gender and physiological state. Furthermore, whole grain foods fit very well into the promotion of a sustainable diet. A diet high in plant-based foods, including whole grain cereals, would be associated with less environmental impact than currently consumed diets in European countries.

Denmark has demonstrated the success of a whole grain public-private partnership between the health sector, the government and industry. Well-aligned communication, product development and regulatory activities can result in a major increase of whole grain consumption. Many factors other than nutrition guidelines and health messages on products are important in influencing consumption.

Health benefits of cereal foods and their components: an overview

Major food epidemiology studies, which started 20-30 years ago, have shown increasingly convincing associations of the benefits of increased whole grain (WG) and cereal fibre consumption for a wide range of health specific benefits, including reduced mortality. An overview of recent publications can be found in a previous Conference report in this publication[1] and in the 'Health studies on whole grains' database of the Whole Grains Council.[2] Wheat was usually the grain studied, but in studies in Northern Europe, it was often rye.

Professor Gabriele Riccardi (Department of Clinical Medicine and Surgery, Federico II University, Naples, Italy) reminded us that cereal foods are the most relevant source of carbohydrates in the human diet. They provide a substantial contribution to energy intake and play an important role in substrate metabolism.

Riccardi first reviewed the most recent epidemiological evidence for WG and cardiovascular disease (CVD). A systematic review and meta-analysis showed that habitual consumption of WG is associated with lower incidence of CVD[3] (see **Figure 1** on next page). Further, an inverse dose-response relationship exists between WG consumption and CVD and total mortality.[4] For diabetes, Riccardi referred to a recent systematic review and meta-analysis which also showed a similar dose response relationship between WG consumption and the risk of type 2 diabetes.[5] In both cases, most of the benefits were observed with an intake of up to two WG servings per day, whereas no benefits were seen with refined grain consumption.

Riccardi then focused on a recent intervention trial from his own laboratory which showed that a diet rich in WG improves insulin action and plasma triglyceride levels in the postprandial period.[6] Further, the postprandial triglyceride response was correlated with fasting plasma levels of alkylresorcinols, which are known to be biomarkers for WG consumption.

Mechanisms underlying the associations of WG with CVD and diabetes are linked to carbohydrate digestibility in the small intestine (lowering postprandial glucose, insulin and lipid rises) and to fermentation of undigested carbohydrates in the colon.

A key point made by Riccardi was that, due to the important role of the colon for WG health effects, many intervention studies (e.g. four weeks only) are too short. This may contribute to the varying results of these studies (in contrast to the convincing associations with health benefits in epidemiology studies). Further, the lack of information on postprandial metabolism in many intervention studies may contribute to the underestimation of the importance of WG for health.

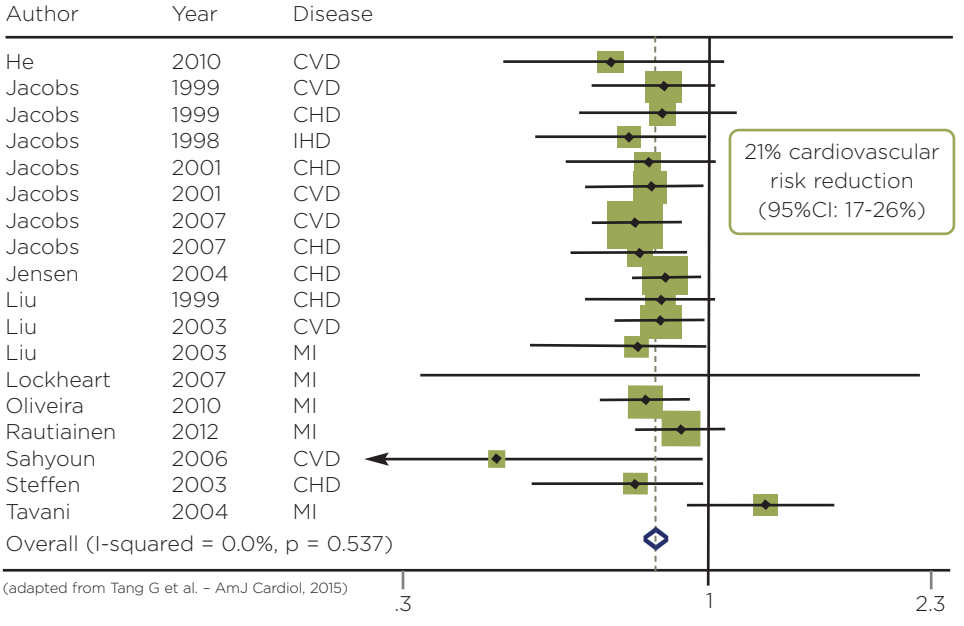
The exact components of cereals able to influence these mechanisms are not yet completely elucidated. However, the key role of the amount of cereal fibre has been clearly established.[7] Furthermore, nutrient composition, food structure, glycaemic index and polyphenol content have been shown to play an important role. Cereal species and products vary in these components and in structure, and this explains why their impact on disease risk factors may differ.[8]

Having summarised the epidemiological evidence for long and short-term benefits of WG, Riccardi drew our attention to the importance of a sustainable diet for ensuring food security and protection of the world's ecosystem. In respect to their impact on CO2 emissions (their carbon footprint), WG products compare favourably with animal products and most other vegetable products (see **Table One**).

Cereal fibre and whole grain: impact on gut microbiota and health

Professor Nathalie Delzenne (Metabolism and Nutrition Research Group, Louvain Drug Research Institute, Université Catholique de Louvain, Belgium) then delved deeper into one of the possible mechanisms by which WG may exert its beneficial effects, that is by correcting dysbiosis which is a term used for a microbial imbalance on or inside the body. Obesity and type 2 diabetes in man are associated with dysbiosis (for review see reference 10) that refers to changes in the composition and/or function of the gut microbiota which can, in turn, alter the gut barrier function. Dysbiosis allows the translocation of bacterial elements, such as lipopolysaccharides which can then alter host metabolism.

Figure 1: Habitual Consumption of Whole Grain is Associated with a Lower Incidence of Coronary Diseases (forest plot between highest and lowest amounts of whole-grain intake and CHD risk)



(adapted from Tang G et al. – AmJ Cardiol, 2015)

Key: CHD: coronary heart disease; CVD: cardiovascular disease; MI: myocardial infarction Horizontal axis shows effect size. Boxes on the left hand side of the vertical axis indicates that the result favours WG consumption.

Table One: Carbon Footprint of Whole Grain and other Food Products

Adapted from Gerard Kramer, Blonk Consultants 2015[9]

Product (ready-to eat)	kg CO2-equivalent per kg product	Moisture %	kg CO2-equivalent per kg product dry matter
Beef	46.7	74,4 (raw)	180
Cheese, Gouda	9.2	39,3	15
Pork	7.7	52,0	16
Chicken	5.1	52,0	11
Salmon	3.9	64,2	11
Egg	3.3	76,2	14
Herring	2.0	65,0	5,7
Tomato	1.7	95,4	37
Cashew Nuts	1.6	2,9	1,7
Milk, semi-skimmed	1.2	89,4	11
Crispbread	1.0	6%	1,1
Bread, white	1.0	37,3	1,6
Bread, rye	0.9	46,2	1,7
Bread, wholemeal	0.9	38,8	1,5
Carrots	0.7	90,4	7,3
Potatoes	0.7	78,0	3,2
Cereal, wholegrain	0.7	11,0	0.79
Apple	0.5	85,8	3.52

There is a wealth of evidence from animal studies that WG have prebiotic properties which can correct dysbiosis. However, there is also good evidence that WG can modulate the human gut microbiota to improve glycemia and to reduce inflammation (see **Figure 2** on next page). It is likely that the aleurone fraction of WG has the best prebiotic properties and that the arabinoxylan fibres in this fraction, play a key role.[11] The resistant starch fraction of WG products is another potential candidate.[12] Delzenne also pointed out that, apart from the different components of WG, different particle sizes with similar nutrition components can modulate gut microbiota in different ways (unpublished data).

Potential mechanisms by which WG fractions exert these prebiotic properties include the increase in *caecal bifidobacteria* with subsequent caecal and colon enlargement. Some wheat bran components can modulate other types of bacteria (e.g. *roseburia spp. bacteroies/prevotella spp.*) which can help to reduce systemic inflammation and adipogenesis (the process of cell differentiation by which pre-adipocytes become mature white adipocytes).

How then do the changes in the gut bacteria exert effects on the host metabolism? Possibly by the production of bioactive metabolites (conjugated linoleic acids, short chain fatty acids etc), through changes in gut endocrine functions (e.g. increase in glucagon-like peptide-1), and/or the general improvement of gut barrier function.[13]

Delzenne concluded by referring to the fact that the gut microbiota evolve with age, and this must be considered in any targeted intervention with a mixture of prebiotics, including those from whole grain. There is still much to discover in the relationship of whole grain consumption to changes in the gut microbiota; only the tip of the iceberg has been explored so far. However, we must be careful to remember that many of the beneficial properties of whole grain are probably mediated through mechanisms that do not involve the microbiota.

Cereal fibre and psychological wellbeing in young and middle-aged adults

Dr Clare Lawton (Leeds Nutrition and Behaviour Group, School of Psychology, University of Leeds, UK) made her initial point the fact that many people do not meet the current recommendations for fibre intake.[14] She wondered if short-term gastrointestinal symptoms could act as barrier to compliance?

She then gave an overview of the emerging epidemiological evidence of the psychological benefits of cereal fibre and whole grain consumption,[15, 16] before she provided details of two short-term intervention trials that her own team had conducted.[17] Low fibre consumers (<15 g/day) increased their fibre intake by incorporating high fibre breakfast cereals and snacks into their usual diet for two weeks in these two studies (Study 1: n=153 males and females; Study 2: n=23 females). Daily ratings of psychological wellbeing were completed in all studies. Significant improvements were found in subjective perception of general wellbeing relative to baseline – feeling less fat, stress, mental and physical tiredness, difficulty concentrating and more slim. In Study 1 participants also reported feeling significantly more mentally alert, happy and energetic during the intervention. In general these benefits increased with increasing cereal/fibre consumption. In a third study[18] a randomised control trial was executed, comparing the effects of two 12-week dietary interventions (general healthy eating alone [HE] and HE plus advice to increase fibre [HE+F] intake to 25 g/day) in 71 overweight women. Wellbeing symptoms improved significantly irrespective of diet. However, those following the HE+F diet felt significantly less fat than those following the HE diet across all 12 weeks and slimmer than those on HE alone during weeks 5-12 of the intervention (see **Figure 3**).

Figure 2: The Role of Cereal Products as Prebiotic Fibres

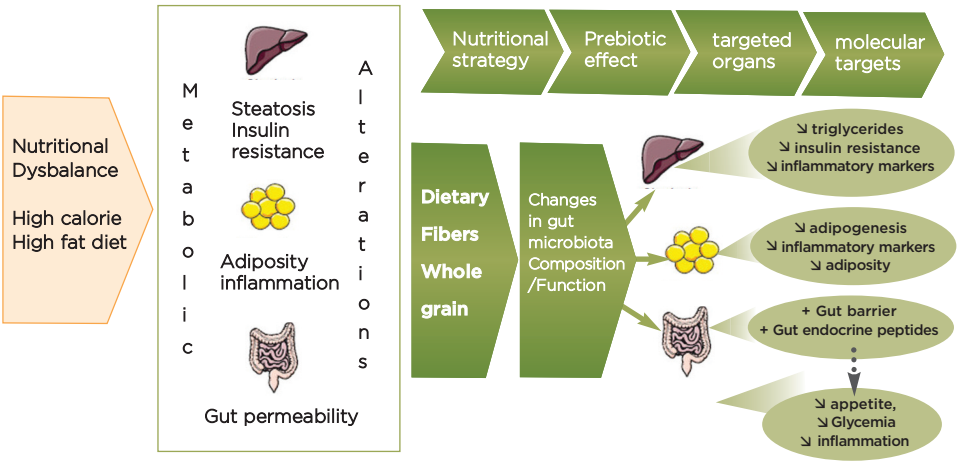
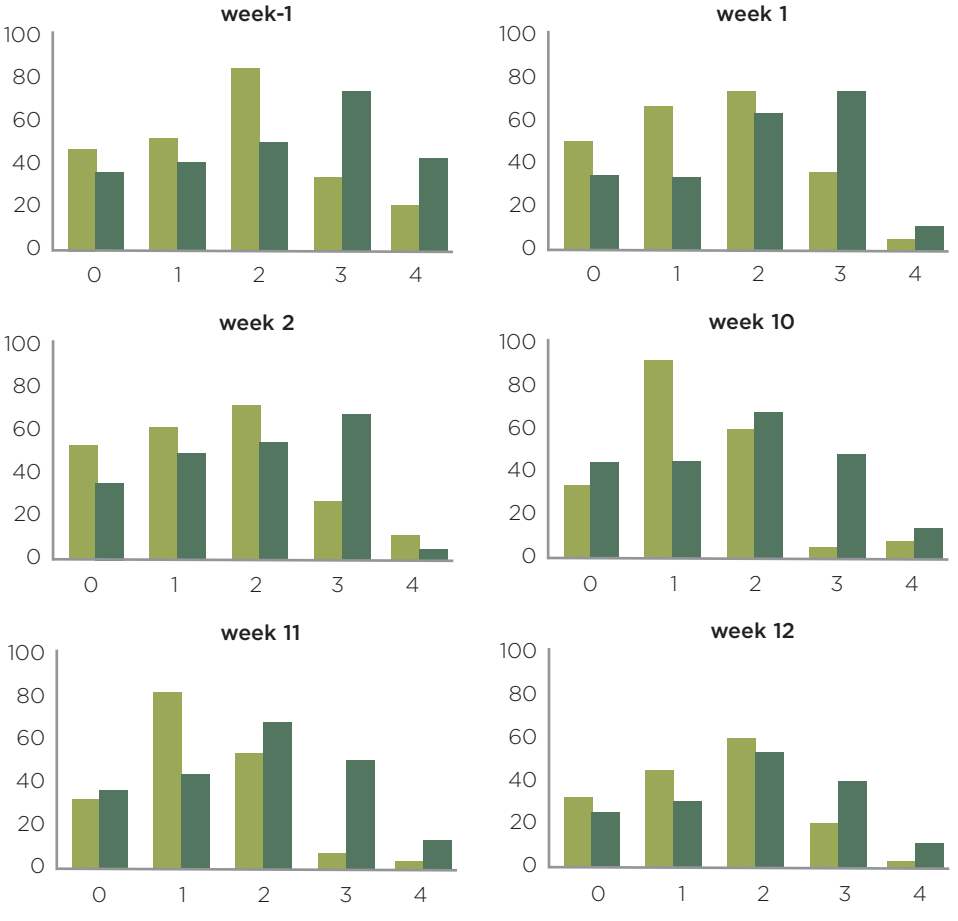


Figure 3: Summary of Effects of Healthy Eating and Healthy Eating plus Fibre Diets on Likert Scale Subjective Ratings of 'feeling fat' over 12 weeks of Intervention



Key: ■ HE: general healthy eating alone; ■ HE+F: HE plus advice to increase fibre intake to 25g/day.
The horizontal axes represent Likert scale subjective ratings (0=none, 1 = minimal, 2=moderate, 3=a lot/very, 4=extreme).
The vertical axes represent the frequency of ratings within each category.
Data are shown at baseline (pre-intervention), early intervention (weeks 1-2) and late in the intervention (weeks 10-12).

Lawton concluded that, although the majority of the population are deficient in fibre intake, encouraging consumption of products high in wheat bran offers an acceptable strategy to increase dietary fibre intake and can produce improvements in psychological wellbeing in a relatively short period.

Science-based health messages to consumers and effective ways for increasing whole grain consumption

Professor Inge Tetens (National Food Institute, Technical University of Denmark, Denmark) started her session by providing an overview of the scientific substantiation of various categories of health messages to consumers on WG. Dietary guidelines are communicated in various ways and in some cases as quantitative advice. Some food-based dietary guidelines, including specific guidelines on WG consumption, are based primarily on observational data, i.e. the associations between WG intake and health outcome and/or risk of disease[19] (see **Table Two**).

She reviewed the scientific substantiation required in the legislation for nutrition and health claims in the European context. This includes a definition and characterisation of whole grains and/or the whole grain product, a definition of the claimed effect and substantiation that the claimed effect is beneficial to human health, and substantiation of a cause and effect relationship from randomised controlled studies in the target population and possibly other supportive data. So far, no authorised claims for whole grain currently exist in EU because, along with other factors, no common definition of whole grain existed at the time the applications were submitted.

Professor Tetens then discussed some 'best practice' examples of effective ways for increasing consumption of WG. In Denmark, the sustained activities of the unique Whole Grain Public-Private Partnership (PPP) took place from 2008 onwards. This PPP had partners from Government (the Danish Food Administration), industry and, last but certainly not least, the health sector, including major disease-health associations, (e.g. the Cancer, Heart and Diabetes Association) and clinical dietitians. Stimulated by this active partnership, a national definition of WG was established, criteria for WG products were set and the availability of WG products was markedly increased by major industry efforts in product development. Whole grain consumption was stimulated by communication campaigns targeted at a range of consumer groups, including groups with minimal WG consumption, such as adolescent girls and boys. The evolution and factors leading to the success of this partnership have been described comprehensively.[23]

Table Three shows how the Danish PPP has been successful in raising WG intake; it compares consumption in g/day during the periods 2000 to 2004 and from 2011 to 2013.[24] Tetens concluded, from this case study, that many factors other than health messages on products are important for population changes in WG consumption.

Discussion

Epidemiology studies on WG have, and are being, executed mainly in the USA and on a smaller scale in Europe and other parts of the world. In the majority of studies WG wheat products are the main grains consumed. However in studies in Northern Europe, WG products based on rye and oats are important. Overall, the evidence from studies, on all types of whole and refined grains, justifies them being taken into account in the development of dietary guidelines. Further, the evidence also justifies the generic recommendations for replacing refined grain products by those based on WG.

The interest in a sustainable and eco-efficient food supply is growing rapidly. Sustainability covers a wide range of factors and a sustainable diet is important for ensuring food security and protection of the world's ecosystem. In respect to their carbon footprint, WG products compare favourably with animal products and most other vegetable products.

What further research is needed? This symposium highlighted four aspects for research on WG and its components:

- Long-term human intervention trials
- Studies on short-term psychological benefits which may also motivate consumers to eat more WG and grain fibres
- Research in the rapidly expanding area of the impact of the human microbiome on health and wellbeing
- Studies on best practices for increasing the consumption of WG.

More information about this session, including pdfs of all presentations, is available at: **www.healthgrain.org**

Table Two: Examples of Quantitative Food-based Dietary Guidelines for Whole Grain in Europe

Country	Dietary Guideline
Austria	Four servings of grains, breads, pasta, rice or potatoes a day. Prefer whole grain products.[19]
Denmark, Norway, Sweden	At least 75 g whole grains/10MJ/day, or 90 g/day for men and 70 g/d for women.[19]
Germany	Ample cereal products and potatoes. 'Bread, grain flakes, pasta, rice, preferably from whole grain, and potatoes contain plenty of vitamins, minerals and dietary fibre as well as phytochemicals. Consume these foods preferably with low-fat ingredients. At least 30 grams of dietary fibre daily, especially from whole grain products, are recommended.'[20]
Greece	About eight servings of cereals and cereal products, preferably non-refined ones, including bread.[21]
The Netherlands	Eat at least 90 g brown bread, whole grain bread or other whole grain products daily. Replace refined grain products by whole grain products.[22]

Table Three: Change in Whole Grain in Denmark 2000-04 and 2011-13 (g/day)

	n	2000-2004	*n*	2011-2013	Increase %
Children (4-14 yrs)	1159	28	762	58	107
Men	2189	39	1546	65	66
Women	2503	28	1643	51	82
Aults (15-74 yrs)	4692	33	3189	58	76

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