Cereal Foods and Health

New results and science-based nutrition guidelines

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Organised by the HEALTHGRAIN Forum

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Recent epidemiological studies, in populations with higher intakes of whole grain, have extended and confirmed the evidence from previous findings showing an association between whole grain cereal or cereal fibre consumption and prevention of several non-communicable diseases. Although the results from human intervention studies are not all consistent, we now have greater insights into possible mechanisms for whole grain effects and these should justify attempts to conduct larger trials. Whole grain cereals contain a vast array of nutrients and bioactive compounds, some of which are more bioavailable after processing. However, the effect of the whole food may be more than the sum of its parts. Many factors play a role including other meal components, the physiology and genotype of the consumer and their gut microbiota. For progress to be made, researchers need to characterise whole grain and its active components more accurately and to understand how all factors interact to affect metabolic and physiological functions well beyond the gut. Recent dietary guidelines have emphasised the consumption of cereal fibre and fibre rich whole grain; the expansion of the evidence base should lead to more specific guidelines for cereal food consumption at the population level.

The worldwide epidemic of non-communicable diseases (NCDs) has developed in parallel with dramatic lifestyle changes, said **Professor Gabrielle Riccardi** (Federico II University, Naples, Italy), the Co-chair of the symposium. He illustrated how rising prevalence rates of obesity and diabetes in the past 50 years coincided with dietary changes such as an increase in meat consumption and, in most countries, a decrease in cereal consumption.

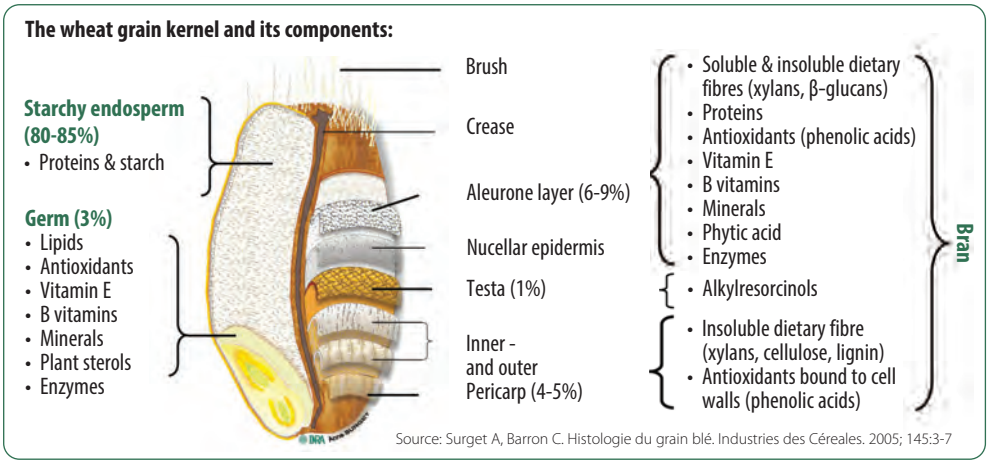
However, associations between cereal food consumption and health outcomes vary, depending on many factors such as of the variety of cereal, its form (whole grain or refined), the fibre content, food structure, glycemic index, polyphenol content, and micronutrient composition. Epidemiological surveys consistently show an association between cereal consumption (mostly whole grain) and prevention of several NCDs, however, the mechanisms involved are still not well understood.

The current American Society of Nutrition's position, based on the state of the science, is that consumption of foods rich in cereal fibre or mixtures of whole grains and bran is modestly associated with a reduced risk of obesity, Type 2 diabetes and cardiovascular disease. The data for whole grains are limited primarily because of varying definitions among epidemiologic studies of what, and how much, was included in that food category. In contrast, the European Food Safety Authority (EFSA) did not issue a positive opinion for whole grain claims on the grounds that the active component was not sufficiently characterised, and because cause and effect had not been established. Professor Riccardi believes that more research (particularly human intervention studies) is needed to fill this gap and provide solid ground for more specific guidelines for cereal food consumption at the population level. This was the premise on which this symposium was convened.

Describing the composition of the wheat grain kernel with its three major components (bran, germ and endosperm) containing many important bioactive constituents (**Figure 1**), he reminded us of the HEALTHGRAIN Forum definition of whole grain (**Figure 2**) and the cereals which would be included in this definition (**Figure 3**).

Figure 1: The Wheat Grain Kernel and its Composition

- **The kernel has 3 major parts:**
  - **Bran**
  - **Germ**
  - **Starchy endosperm**
- **Whole grain flour contains the bran, the germ and the endosperm**
- **Bran and germ have a high content of fibre, micronutrients (vitamins, minerals, trace-elements) and bioactive plant compounds (antioxidants, sterols, etc)**



Source: Surget A, Barron C. Histologie du grain blé. Industries des Céreales. 2005; 145:3-7

Figure 2: Whole Grain Definition

Whole Grain Definition Developed by the HEALTHGRAIN Consortium

- Whole grains shall consist of the intact, ground, cracked or flaked kernel after the removal of inedible parts such as the hull and husk. The principal anatomical components - the starchy endosperm, germ and bran - are present in the same relative proportions as they exist in the intact kernel.
- Small losses of components - i.e. less than 2% of the grain/10% of the bran - that occur through processing methods consistent with safety and quality are allowed.

Figure 3: Cereal Grains included in the Whole Grain Definition

Wheat, including spelt, emmer, faro, einkorn, kamut, durums
Rice
Barley, including hull-less or naked barley but not pearled
Oats, including hull-less or naked oats
Rye
Maize (corn)
Millets
Minor Grains: sorghum, teff (tef), triticale, canary seed, Job's tears, fonio, black fonio, Asian millet, wild rice
Pseudo Cereals: amaranth, buckwheat, tartar buckwheat, quinoa

Whole grain intake and colorectal cancer: results from the HELGA and EPIC cohorts

Dr Anja Olsen from the Danish Cancer Society Research Centre, Copenhagen, Denmark, presented associations between dietary fibre, whole grain intake and incidence of colorectal cancer, in a large Nordic cohort of 120,000 adults (HELGA), followed up for 12 years. Intake of dietary fibre, especially from cereal sources, and consumption of whole grain products was associated with a lower incidence of colorectal cancer. The strongest association was observed for whole grain wheat, with non-significant associations for oats or rye. The association was strongest and most consistent for men and there was tendency for the strongest effect to be for distal colon cancer. Dr Olsen stressed the importance of using biomarkers for whole grain intake. The phenolic lipids, alkyl resorcinols are only present in bran of whole grain wheat and rye and they have been validated as a biomarker for whole grain in intervention and cohort studies. She reported on a new (unpublished) study using plasma levels of alkylresorcinols as biomarkers for whole grain intake in the EPIC cohort across 10 European countries. Preliminary results showed a lower incidence of distal colon cancer among those with highest levels of alkylresorcinols, although results for colon cancer overall were not statistically significant. There was no difference in the association by whole grain source (wheat vs. rye). Heterogeneity was observed across the different regions in the EPIC study, with Scandinavia and Middle Europe countries showing the highest reduction in relative risk related to the biomarker of whole grain intake. These results suggest that whole grains may play a role in protecting against colorectal cancer possibly via their fibre content, although more studies are needed to confirm this.

Health benefits of whole grain wheat: intervention study clarifying underlying mechanisms and the role of polyphenols bound to dietary fibre

The next speaker, **Dr Paola Vitaglione** (Department of Agriculture and Food Science, University of Naples, Italy) focused on the mechanisms by which cereal dietary fibre may exert its beneficial effects. Whole grain cereals, especially wheat and rye, contain bioactive polyphenols, mainly ferulic acid, bound to dietary fibre. Her study was conducted to evaluate whether these polyphenols contribute to the health benefits of whole grain via their antioxidant, anti-inflammatory or prebiotic activity.

The approach underlying the double arm randomised intervention trial was quite different from previous studies in that healthy overweight/obese subjects having a low intake of fruits and vegetables and a very low level of physical activity were recruited. Subjects in the experimental arm were asked to not change their lifestyle except for replacing a fixed amount of refined wheat products (bread and/or pasta) with a whole wheat product for two months; subjects in the control arm consumed only refined wheat products. Several biomarkers of inflammation, antioxidant and prebiotic activity were measured in blood, urine and faeces, together with anthropometric indices and body fat bio-impedance analysis at specific time points over the study period.

Results suggested that polyphenols bound to dietary fibre in whole wheat might play a role in the oxidative and inflammatory processes underlying obesity. Moreover, a clear interplay between microbiota of volunteers and whole wheat consumption was found. Detailed results of the study will be published in a scientific journal in due time.

Whole grain wheat intake – impact on weight loss, body composition and cardiometabolic factors – results from intervention studies

In the next session, **Professor Penny Kris-Etherton** and **Dr Kristina Harris** (Department of Nutritional Sciences, Pennsylvania State University, USA) focused on the effects of whole grain intake on weight loss and, in particular, its effect on visceral adipose tissue (VAT) mass.

Although epidemiological studies have found a lower rate of weight gain and reduced risk of cardiometabolic syndrome (CMS) associated with increased consumption of whole grain, intervention studies have not shown consistently that whole grain consumption enhances weight loss or improves insulin sensitivity.

A recently published meta-analysis concluded that whole grain consumption does not decrease body weight compared to the control, but there may be a small beneficial effect on body fat. Professor Kris-Etherton and her group have conducted clinical trials which investigate the effect of whole grain on visceral adipose tissue in more detail. In one study with 50 obese men and women with metabolic syndrome consuming hypocaloric diets (whole grains or refined grains) for 12 weeks, there was no difference in weight loss between the groups but there was a greater decrease in abdominal fat and a greater decrease in C-reactive protein (a marker of inflammation) in those consuming whole grain. A new trial reported elsewhere at the Congress showed that the greater the increase in the biomarker for whole grain intake (alkylresorcinols), the greater the reduction in visceral adipose tissue. Changes in VAT were also correlated with changes in fasting insulin. These preliminary results suggest that the changes in CMS risk factors might be mediated via insulin, and specifically insulin sensitivity, which is correlated with VAT.

Global dietary whole grain recommendations: harmonised or multifarious message?

In the final session, **Professor Chris Seal** (Human Nutrition Research Centre, School of Agriculture, Food and Rural Development, Newcastle University, UK) reminded us that although whole grain has now been defined (**Figure 2**), consensus definitions of whole grain foods do not yet exist. For example, in the USA, whole grain foods must contain more than 51 per cent by weight whole grain ingredients and at least 8 g whole grain per serving. In the UK, the IGD Working Group recommended that foods should contain a minimum level of 8 g whole grain per serving. Thus, it is not surprising that the level of emphasis placed on dietary whole grain intake is highly variable across the world. Professor Seal and colleagues quantified this variation using a combination of literature searches and direct inquiry, reviewing the presence/absence of recommendations, their rationale, their wording and their diversity in emphasis (i.e. 'primary' – with an emphasis on whole grain, or 'secondary' – if just linked to cereal, fibre or carbohydrate). In some regions (more than half of the 50+ countries surveyed), dietary recommendations for whole grain intake do not exist. The recommendations that do exist can be categorised as: generic, generic quantitative and specific (**Table One**).

Table One: Types of Recommendations for Whole Grain Foods

Type	Whole grains
Generic	'Prefer whole grain wheat when eating cereals' (Israel)
Generic quantitative	Consume at least half of all grains as whole grain; eat 2-3 servings (>48 g) of whole grains daily (US)
Specific	Eat 75 g of whole grain per day per 10 MJ (2400 kcal) energy; Eat a variety of whole grains, emphasising grains high in fibre (wheat, rye, oats, barley) (Denmark)

For some countries, there are defined whole grain dietary recommendations, supported by policy and health promotion campaigns. However, quantitative recommendations are related to grams per day (e.g. USA: 48 g/d) or number of servings per day (e.g. Australia: 4-9 servings for women and 6-12 servings for men). In other countries, such as UK, whole grain recommendations are secondary, forming part of broader guidelines on carbohydrate and/or fibre intakes or even general healthy eating guidelines. Where this occurs, the recommendations are typically less prescriptive. Greater harmonisation would provide more clarity, said Seal, but to achieve this, future trials might have to be larger and better controlled, and may have to focus on single grains. Until then, the lack of a harmonised message may result in potential confusion for the consumer, lessen the impact of public health messages and pose barriers to international trade for the food industry.

Question session and panel discussion

Professor Kaisa Poutanen (VTT and University of Eastern Finland) chaired the Open Session, stressing in her introduction that nutritionists should talk more about the nutrient density of whole grain foods, not just their health benefits. A comment was made that it was a paradox that recommendations (for whole grain cereals) exist, when randomised controlled trials fail to provide proof of benefit. A parallel was drawn with recommendations for fruit and vegetable consumption, where not all studies provided convincing evidence and the effects are variable between types of fruit and vegetables. It is encouraging that some new studies reported in this symposium seem suggestive of an effect of whole grain on fasting glucose, inflammatory markers and visceral adipose tissue, although some of these data were preliminary. Another commentator remarked that changes in visceral fat could be masked because many studies were controlled for energy intake; if whole grain cereals help reduce body fat, this is likely to be largely via reduced energy and, thus, ad libitum studies are needed to test satiety effects of cereals.

In conclusion, the presentations at this symposium have shown that whole grain cereals contain a vast array of nutrients and bioactive compounds and progress has been made in identifying some possible mechanisms. In the future, key tasks for researchers include being able to identify the active components in different whole grains and elucidate their mechanisms, as well as to quantify their presence in foods. This could also help to justify larger clinical trials, which would be more likely to yield significant results to reinforce the consistent message emerging from the epidemiological studies. As with all foods, the effect of the whole food is more than the sum of its parts and is affected by many factors including other meal components, the physiology and genotype of the consumer and their gut microbiota. We are only just beginning to understand how these all interact to affect metabolic and physiological functions well beyond the gut. There appear to be multiple pathways by which whole grain cereals may exert their effects, as suggested in **Figure 4**. The role of whole grain foods will continue to be a focus of discussion, and future research will provide us with even stronger evidence on which to base more specific dietary guidelines for the population.

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

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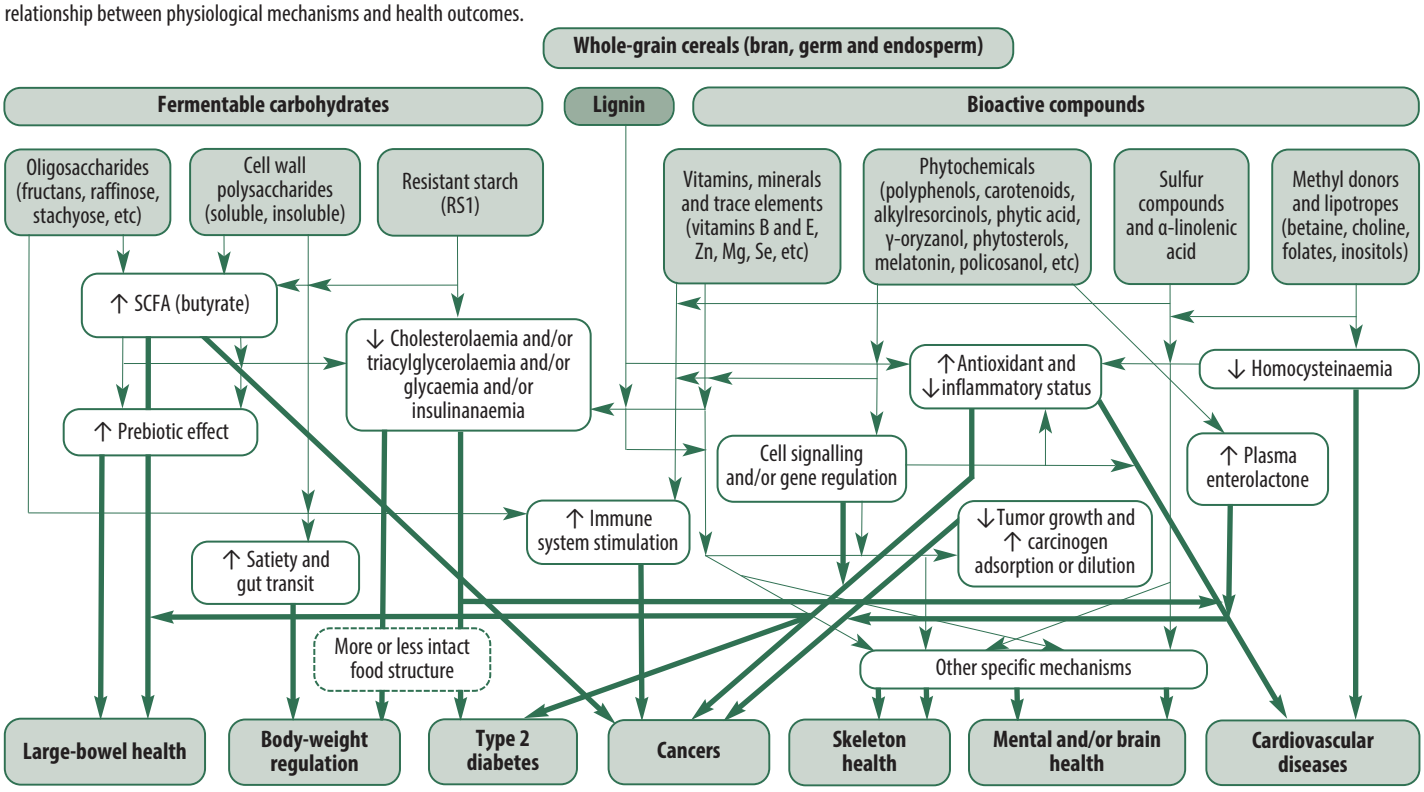
Figure 4: Current and New Proposed Physiological Mechanisms Involved in Protection by Whole Grain Cereals

The thin arrows (⟶) indicates the link between whole-grain bioactive compounds and protective physiological mechanisms, while the coloured plain arrows (⟶) indicate the relationship between physiological mechanisms and health outcomes.



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