that may be involved in cardiovascular/haemostatic pro-
tection, lipid metabolism and DNA methylation. Potential protective effects of bound phytic acids
within the colons, of the biocomplex vitamins on ner-
vorous system and mental health, as well as
prebiotics, of compounds associated with skele-
tonal health (e.g. phosphorus, calcium, magnesium,
mannan, copper and vitamin K2, and of other
compounds, such as alpha-linolenic, polisaturated
melanins and para-aminobenzoic acid: also deserve
to be largely more studied. For example, it would be particularly interesting to study
the effect of whole grain products on mental health
issues like depression, insomnia and cognitive de-
cline given that other bioactive compounds, such
as: choline, ferulic acid, magnesium, zinc, copper, iso-
nutrients, polysaccharides and melanins, are also potential
candidates for mental health protection and equil-
ibrium.

Optimizing the binding of bioactive compounds
In addition to discussing the role of bioactive
compounds in relation to health effects, Färder
outlines the many ways for improving cereal product nutri-
tional quality (Figure 3). Thus, a good fermentation
process may lead to a higher content of minerals
such as: selenium, magnesium, iron and zinc.
Secondly, grains with higher levels of bioactive
substances may be obtained via genetics. Thirdly,
the nutritional quality of cereal products may be
increased via technological processes, notably
through reducing the degree of refining and appl-
Yielding fragmentation during processing. Indeed, if
cereal fermentation is largely already used to produ-
ce alcoholic beverages, it may also have a positive
effect on the bioavailability of bioactive substances
and on their increased content in cereal products.
More generally, one should search for increasing
nutritional density of whole grain cereals and/or
their fractions as already largely practiced in develop-
ing countries, notably in Africa and Asia.

The whole grain package
The contents of individual bioactive compounds in
whole grain may seem too low for them to have any
significant or lasting physiological effects. It is beco-
ming more and more evident that the synergistic
action of several bioactive compounds contributes to
health protection and/or the maintenance of one
physiological function, not just one compound.
Figure 1 and 2 illustrate this concept of "whole grain
package": therefore, obesity/body weight regulati-
on, cardiovascular diseases, type II diabetes, can-
cers, gut, mental/immune system and skeleton
health; must be potentially present, at least, in
14, 37, 32, 10, 26 and 16 different bioactive com-
ponents and/or groups of components respectively.

Until today, research has tended to focus on the
study of isolated effects of individual bioactive com-
ponents based on a relationship approach. The com-
tended physiological effects of the bioactive com-
ponents would be now more interesting to in-
vestigate based on a more integrative and holistic
approach, but this is probably more difficult to appre-
cept. Today, the development of nutrigenomics
presents new opportunities for studying further such
combined and complex effects. With nutrigenomics,
nutrition looks at the impact on the genes, protein
synthesis and metabolic pathways in body tissues and
cells following diet or food consumption. In the
end, due to the gap between observational studies
and the elucidation of the causal physiological me-
chanisms involved, there is a real need for inter-
vention studies with complex whole grain products
in humans.

For more information see also:
EUP5, Whole grain Fact Sheet (2019)
http://www.eufic.org/article/en/expo/pid/Whole
grain_Fact_Sheet

Whole grain foods and health
Cereal foods are an essential part of the daily diet. Nutrition epidemi-
ology research increasingly demonstrates that a diet rich in whole
grain based foods assist in health maintenance and thus lowers
the risk of non-communicable diseases. An overview of all bioactive
compounds in whole grains, their potenti-
al health effects and mechanisms involved is given in a major review
paper with over 1000 references (Nut Rev 2010 23(6):131-146).
In order to inform wider audiences, the author, Dr. A. Färder has pre-
pared for the HealthGrain Forum the summary presented in this leaflet.

Health-protective mechanisms of whole grain
The HealthGrain Forum (2009-2010) has substantially strengthened
the scientific basis for a new generation of cereal based products
with enhanced health benefits. The HealthGrain Forum (www.healthgrain.eu) was initiated in 2010 for
coordinating and promoting the networking and communica-
tion activities. Already 55 member organisations joined, with an even
broader focus in Europe and in a few other regions in the world, to
formulate a Strategic Research Agenda and to develop a range of communication activities, with the overall
aim of increasing consumers’ intake of protective components in whole grains.

Website www.healthgrain.org

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WHOLE GRAIN BIOACTIVITY

Whole meal vs. white flour. 2.5 - 5 x higher levels

Synergistic effects
Beneficial physiological effects in humans

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Source
Health-protective mechanisms of whole grain cereals: involved beyond fibre?

The physiological mechanisms involved

Epidemiological research indicates that the consumption of whole grain products significantly protects against obesity, type 2 diabetes, cardiovascular disease and some cancers, especially within the digestive tract, the effect being the most considerable against type 2 diabetes. How do whole grain foods offer protection against these chronic diseases? Human intervention studies have notably shown that increased whole grain food consumption may contribute to an improved intestinal health, a lower BMI (Body Mass Index), a healthier blood glucose profile, an improved likelihood of glucose control, increased insulin sensitivity, lower homocysteine levels (a cardiovascular risk factor) and reduced inflammatory markers. The preservation of intact food structure (i.e., more or less intact cereal kernels) may also lead to an improved feeling of satiety that is important in weight gain control. Whole grain products are also generally rich in fibre, antioxidants, anti-inflammatory and that are all potentially protective. In addition, whole grain products may lead to increased butyrate production (protective against tumour growth) within the colon due to resistance starch (the fibre fraction that is not digested in the small intestine) and fibre fermentation. Some antimicrobials like phytic acid, tannins, saponins and inhibitors of enzymes (e.g. proanthocyanidins and oxidative) may also possibly affect starch hydrolysis by the different enzymes in the small intestine. It is now well demonstrated that the consumption of low-GI (Glycemic Index) whole-grain products either at dinner or at breakfast positively influence the glycemic and glucoregulatory (glucose control) at the following meal (the "second-meal" effect), an effect which may contribute to the long-term metabolic benefits of low-GI diets.

Besides these quite well-known mechanisms, a whole grain also contains a multitude of other bioactive substances. The content of some bioactive substances may however seem too low for reaching a significant effect. But according to Fardeau, it becomes increasingly obvious that the combination of all these bioactive substances might have positive synergistic health effects; not only within the intestine or towards cardiovascular diseases, glucose metabolism and weight management, but also in new areas such as bone health and mental health (see Figure 2). Let's now have a detailed look at the main physiological effects of whole grain bioactive compounds:

Whole grain cereals as a rich source of fibre

Whole grains are primarily a rich source of fibre. The fibre content of whole wheat varies between 9 and 17 grams per 100 grams. That is more than vegetables, which usually have about 2 grams per 100 grams edible portion. Thus, consuming whole grain cereal products is undoubtedly beneficial in reducing the fibre intake from the 10-15 g/day eaten by most Western populations to the recommended level of about 30-35 g/day.

Whole grain cereals are rich sources of inulin-like resistant fructans and resistant starch. Fibres from whole grain foods are beneficial for gut health. Inulin-like fructans, which are not fer-mented in the colon, favour an increased transit time and promotes faecal bulk, two parameters that proba-bly prevent colon cancer by inhibiting carcinogens and reducing time in contact with epithelial cells. Cereal fibres also increase satiety and help con- trol body weight. Fiber fermentation is also associa-ted with an increased production of short-chain fatty acids (SCFAs) that are associated with a lower risk of cancer, favouring the development of a healthy colo-nic microbiota (i.e. a probiotic effect). However, the way fibres may be beneficial for human health is multi-factorial and it involves other physiological mecha-nisms such as hormonal effects or decreased gastric emptying rate due to viscosity fibre.

Whole grain cereals as rich sources of anti- carcogenic compounds

This anti-carcogenic effect is mainly attributed to the antibacterial and anti-inflammatory properties of several lignans, bioactive lipids, and antioxidants. Stress and inflammation are involved in cancer antio- logy. Phenolic acids, flavonoids, carotenes, vitamin E, α and γ-tocopherols, lignin phytoestrogens, sterol saponins (found mainly in card), phytic acid and sele-nium are all potential suppressors of tumour growth, but human, animal and in vitro cell studies indi-cate that their mechanisms of action may differ. To summarize, it is possible to distinguish between the anti-carcogenic effects of resistant fibre (including resistant starches), non-starch polysaccharides and SCFAs by directly absorbing or diluting carcinogens (through increased faecal bulk by sodium bicarbonate), or indirectly by decreasing colon pH through Short Chain Fatty Acid (SCFA) production and increasing butyrate production. The role of phytochemicals is still under study but there are several antioxidant, anti-carcogenic and anti-inflammatory properties of whole wheat.

Whole grain cereals as a rich source of magnesium and anti-oxidants

Not only do whole grains contain fibre, but also rele-vant amounts of magnesium and antioxidants. The high magnesium content may partly explain the be neficial effect of whole grain foods on insulin sensi-tivity and risk of type 2 diabetes. Magnesium increases insulin sensitivity and it is known that diabetes is often associated with a lack of magnesium. In a whole grain there are also different substances that contribute directly or indirectly to protect the body from increased oxidative stress. At least 30 bioactive compounds might be involved: Think of poly-phenols, carotenoids, vitamin E and minerals like si-licon, iron, copper and zinc, as well as a co-factor in antioxidant enzymes, sulphur-containing amino acids, methionine and cysteine that are precursors of thiol antioxidants that are endogenous antioxidants. Even lignans, generally considered as biologically inactive, has been shown to exert a potential antioxidant effect for animals. Antioxidants found in whole grains may also protect the intestinal epithelium against damage by free radicals, such as those produced within the colon through bacteria metabolism. The antioxid-ants in whole grain cereals may therefore act via different, complex, and synergistic mechanisms in vivo. Overall, the benefits of whole grain cereals of whole grain cereals has not yet been consistently validated in humans and requires further exploration.

Other bioactive compounds and potential health effects

Recent findings, the exhaustive listing of bioactive compounds found in whole grain wheat, their content in whole grain, liner and gluten-free diets and their estimated bioavailability, have led to new hypo-theses. The involvement of lignans in colonic butyrate form- ing and gene regulation, and of sulphur compounds in fat and protein, acts instead be considered as endogenous antioxidants. Whole wheat is also a rich in essential fatty acids (polyunsaturated, monounsaturated, and saturated fatty acids).

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