Dietary Whole Grain–Microbiota Interactions: Insights into Mechanisms for Human Health[1–3]

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ABSTRACT

This article summarizes the presentations from the "Dietary Whole Grain–Microbiota Interactions: Insights into Mechanisms for Human Health" symposium held at the ASN Scientific Sessions and Annual Meeting at Experimental Biology 2014 in San Diego, CA, on 28 April 2014. The symposium focused on the interactive effects of whole grains and nondigestible carbohydrates with the gut microbiota with the goal of identifying the benefits of whole grains that are mediated through their effects on the gut microbiome. This theme was addressed by 4 speakers, each with their own unique perspective. Dr. Michael Lefevre reviewed the impact of whole grains on markers of subclinical inflammation, drawing examples from epidemiologic literature, clinical trials, and animal experiments. Dr. Knud Erik Bach Knudsen discussed data from studies he conducted to identify specific carbohydrates that enhance colonic butyrate production. Dr. Michael Keenan presented a chronology of his research program devoted to understanding the mechanisms underlying the metabolic effects of resistant starch, particularly high-amylose maize. Dr. Jens Walter emphasized that whole grains can impact gut microbial ecology by increasing microbial diversity and inducing compositional alterations, some of which are considered to have beneficial effects on the host. *Adv. Nutr. 5: 556–557, 2014.*

The concept of microbial-mammalian cometabolism as a key influence on human health is a hot topic that involves the integration of nutrition, metabolomics, microbiology, genomics/metagenomics, and food science. The role of the gut microbiome in optimizing health has received considerable attention in the nutrition community. Rather than review the sweeping research efforts in this rapidly expanding field, this symposium, entitled "Dietary Whole Grain–Microbiota Interactions: Insights into Mechanisms for Human Health," focused on the interactive effects of whole grains and nondigestible carbohydrates with the gut microbiota with the goal of identifying the benefits of whole grains that are mediated through their effects on the gut microbiome. The objectives of this symposium were as follows: *1*) to understand the current research methods used to study nutrition and gut microbiota; *2*) to understand the roles of particular bacteria in the microbial community of the human large intestine; and *3*) to present novel hypotheses related to the role of gut microbiota in improved human health. Four distinguished speakers addressed the symposium theme, each providing their own unique perspective, describing cutting-edge science in this field and testing key hypotheses relative to the mechanisms of the well-known health benefits of whole grains.

The symposium's first speaker was Dr. Michael Lefevre, USTAR Professor at Utah State University's Center for Human Nutrition Studies and the Scientific Director of the Applied Nutrition Research team. Lefevre's presentation, "Whole grains and markers of subclinical inflammation," first reviewed epidemiologic evidence of the role of whole grains in promoting good health and affecting disease risk specific to inflammation. Cohort studies reveal that small changes in risk could be attributable to whole-grain consumption, but interpretation of this effect is confounded by the possibility that use of whole grains may indicate a healthier lifestyle. In contrast to epidemiologic studies, interventional studies do not demonstrate a clear effect of increased whole-grain consumption on markers of inflammation. Only 1 study found a decrease in circulating C-reactive protein concentrations, whereas all other studies reviewed found no change in markers of inflammation. Issues related to insufficient length of intervention, extent of dietary control, population selection, types of whole grains, and lack of a direct anti-inflammatory effect may underlie these discrepant findings. These findings have been

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[2] The organizer has indicated that related reviews of this symposium will be submitted for publication in an upcoming issue of *Advances in Nutrition*.

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summarized previously in a published review article (1). In particular, he emphasized that one cannot assume that all whole grains have similar physiologic effects. New research conducted in his laboratory demonstrates that whole wheat, whole oats, and whole corn have unique effects on inflammatory responses, metabolism, and gut microbiota composition.

The second speaker was Dr. Knud Erik Bach Knudsen, Professor and Head of the Research Unit on Molecular Nutrition and Cell Biology in the Department of Animal Science, Aarhus University, Denmark. In his presentation, "Microbial degradation and impact on short-chain fatty acids of whole grain complex carbohydrates in the gut," Knudsen posited that the carbohydrates found in cereals may have major effects on butyrate production in the large intestine and described a series of studies he conducted to identify specific carbohydrates that enhance colonic butyrate production. Butyrate is targeted for its beneficial effects on gut health, including maintaining the integrity of the coloncytes. Systemically, this short-chain FA may also promote insulin sensitivity and glucose homeostasis and reduce food intake through release of gut peptides associated with satiety. Knudsen has found that arabinoxylan-rich rye fractions produce the highest level of colonic butyrate production and explained how this carbohydrate source might be used to improve health.

The third speaker was Dr. Michael J. Keenan, Associate Professor of Human Ecology at the Louisiana Agricultural Experimental Station at Louisiana State University, Baton Rouge, LA. Keenan's presentation, "Role of resistant starch in improving gut health and metabolic syndrome," included a chronology of his research program devoted to understanding the mechanisms underlying the metabolic effects of resistant starch, particularly high-amylose maize. He has studied the impact of resistant starches from grains on gut microbial profiles and markers of health in gestational diabetes and in both dietary and genetic animal models of obesity. The primary event in resistant starch action is the manipulation of the gut microbiome and resulting fermentation products. Keenan reported that microbial community shifts associated with resistant starch consumption include increases in *Lactobacillus, Bifidobacterium*, and *Akkermansia.* Along with these shifts in microbiota, insulin sensitivity improves, possibly due to these following secondary mechanisms: *1*) improved gut health and gut barrier function, which lowers the leakage of inflammatory products from the gut to the blood stream; and/or *2*) butyrate stimulation of enteroendocrine cells to increase production and secretion of glucagon-like peptide 1, which is known to improve insulin sensitivity and reduce body fat.

The fourth speaker was Dr. Jens Walter, Associate Professor and Campus Alberta Innovation Program Chair for Nutrition, Microbes, and Gastrointestinal Health at the University of Alberta, Edmonton, Canada. Walter's presentation, "The role of the gastrointestinal microbiota in the health benefits of whole grains," began with the suggestion that dysbiosis of the intestinal microbiota is associated with a large number of the chronic diseases prevalent in Western societies. This dysbiosis, characterized by decreased diversity of the microbiota, is the result of a modern lifestyle that includes a diet low in fiber and high in simple sugars, fats, and protein—a diet that provides poor nutritional support for microbes inhabiting the large intestine. Walter emphasized that whole grains can impact gut microbial ecology by increasing microbial diversity and inducing compositional alterations, some of which are considered to have beneficial effects on the host. For example, in studies with whole-grain barley, brown rice, and the combination of these grains, he found that inclusion of both whole grains led to increases in the *Firmicutes*:*Bacteroidetes* ratio. Also, he found that whole-grain barley consumption resulted in enrichments of the genera *Roseburia, Bifidobacterium*, and *Dialister*, and the species *Eubacterium rectale, Roseburia faecis*, and *Roseburia intestinalis.* These changes were seen despite large interindividual variation in response to the whole grains. The grain combination also produced decreases in peak postprandial glucose and plasma IL-6; the latter decrease was related to abundance of specific taxa.

In summary, new data were presented to demonstrate that consumption of whole grains and complex nondigestible carbohydrates found in whole grains can significantly shift the microbial ecology of the large bowel. These changes were associated with alterations in markers of immunologic function and with improvements in blood glucose control. Collectively, the speakers presented state-of-the-art concepts aimed to determine the role of the gut microbiota in conferring health benefits of whole grains. Important themes highlighted by these presentations were as follows: *1*) the carbohydrates contained in whole grains vary in complexity and structure and, as a result, have different effects on the microbiota; *2*) other diet components such as fat or protein may influence the response to whole grains; and *3*) individual responses to whole grains are varied and influenced by phenotype and genotype. We were also reminded that, in addition to the complex carbohydrates, whole grains contain other bioactive components, such as lignans and polyphenols, that may influence metabolic and immunologic functions independently or in concert with shifts in the microbiota. Clearly, many questions remain to be answered, but the work presented by our speakers has established a strong foundation for future exploration of whole grain–microbiota interactions.

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References

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