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A shift toward a new holistic paradigm will help to preserve and better process grain products' food structure for improving their health effects

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This review aims at emphasizing the role played by physical characteristics and physico-chemical properties of the food matrix on the digestive and metabolic fate, and health effects of grain products. It is today obvious that the food matrix conditions the health effects of food products and that we are able to modify this matrix to control the digestive fate of foods, and the metabolic fate of nutrients and bioactive compounds (reverse engineering). In other words, there is no more reason to consider nutrition in a quantitative perspective (*i.e.*, a food is only the sum of its macro-, micro- and phyto-nutrients) but rather according to a qualitative perspective involving concepts of interaction of nutrients within the matrix, of enzymatic bioaccessibility, bioavailability and metabolic fate in relation to release kinetics in the gastrointestinal tract, and food nutrient synergy. This new perspective on the health potential of foods also reflects the urge to consider preventive nutrition research according to a more holistic and integrative perspective after decades of reductionist research based on the study of the health effects of food components in isolation. To illustrate the importance of food structure, attention has been focused on grain-based products such as rice, leguminous seeds and nuts, and on soft technological treatments that preserve food structure such as pre-fermentation, soaking and germination.

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I have 17 years of research experience at the food science–human nutrition interface. I first worked on cereal products' health potential. From 2006, I worked for 3 years in metabolomics. In 2009, I orientated toward in biblio research with a focus on exhaustive classical reviews, systematic reviews, meta-analyses and position papers: I notably studied the associations between diet-related chronic diseases, deregulated metabolisms and food

groups. At present, I am particularly interested in developing holistic approaches to preventive nutrition for diet sustainability at horizon 2050 with a focus on grain products. I am also expert for the French Agency for Food, Environmental and Occupational Health & Safety.

1 Introduction: a brief history

In 1977, Haber *et al.* (1977)¹ showed, in healthy subjects, that the glycemic response after consumption of apples as whole, puree or juice was all the more faster when the food matrix was unstructured and satiety decreased parallel to the disintegration. It is known that, depending on the kinetics of arrival of carbohydrates in the blood, the metabolic response is very different. In addition, an increased satiety contributes to a better control of food intake and ultimately weight. Today, we talk about rapid or slow sugars, the latter property being used by diabetic patients in their food choices in order to better regulate their blood sugar and insulin levels. In 1986, a study went in the same direction by showing that the act of swallowing foods rich in carbohydrates (sweet corn, apple, white rice and potatoes), rather than chewing, significantly reduced the glycemic response, the effect being similar to the administration of slow carbohydrates.² Finally, in 1991, similar results were obtained in humans following the consumption of pasta or bread made from the same starting ingredient, *i.e.*, durum wheat, pasta resulting in a reduced glycemic and insulin response – *i.e.*, hormonal – compared to bread.³ Thus, the nutritional property is not contained in the durum wheat as such but in the food matrix shaped by the technological process. These three studies clearly showed that, at a some-