by Neil H. Mermelstein

Addressing **Bioavailability & Digestibility**

The bioavailability of nutrients *in fruits, vegetables, and other foods is affected by numerous factors.*
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To provide health benefits, a nutrient in food must be digested and utilized by the body. In other words, the food must be digestible and the nutrient must be bioavailable. The December 2010 Food Safety & Quality column, "Simulating Digestion," in *Food Technology* discussed the design and use of artificial human gastrointestinal tracts, and the January 2011 column, "Measuring Encapsulation Efficacy," discussed encapsulation as a means of protecting or maintaining the bioavailability of compounds during digestion. This month's column will add to the discussion of these topics by summarizing several relevant conferences and symposia.

Nutrient Bioavailability

The bioavailability of pharmaceuticals is specifically defined and rigidly regulated. The bioavailability of nutrients, in contrast, is less defined. Basically, it is the degree to which a nutrient is available to the target tissue after consumption or, as the European Food Information Council (www.eufic.org) puts it, the proportion of a nutrient that is absorbed from the diet and used for normal body functions.

In the human digestive system, food is broken down mechanically and chemically (enzymatically) to release and allow absorption of nutrients. The bioavailability of a nutrient in food is affected by numerous factors such as the food structure, the chemical form of the nutrient, how readily the nutrient is released from the food by chewing, effects of enzymes in the gastrointestinal tract, intestinal motility, health of the person consuming the food, and interactions with drugs and other foods or nutrients (e.g., vitamin C enhances iron absorption while phytic acid binds calcium, iron, and zinc, making them unavailable for absorption).

Knowledge of the bioavailability of nutrients is needed to translate physiological requirements into actual dietary requirements and recommendations, but determining the physiological requirements is difficult. The European Micronutrient Recommendations Aligned (EURRECA) Network of Excellence (www.eurreca.org) is making efforts to standardize assessment methodologies across Europe.

Designing for Digestibility

Although many studies have identified relationships between food structure and composition and the bulk properties, such as shelf life, texture, and flavor, fewer studies have addressed the changes that occur in foods upon ingestion, digestion, and absorption. Accordingly, a symposium titled "Rational Design of Food Delivery Systems: Physicochemical Basis of Food Component Digestion, Release, and Absorption" was presented at the Institute of Food Technologists' Annual Meeting & Food Expo in Chicago, Ill., in July 2010.

Harjinder Singh of Massey University in New Zealand said that there is growing interest in understanding how food material properties can be manipulated under physiological conditions to control the uptake of lipids and lipid-soluble components. He described how the structure of emulsified lipids affects lipid digestion at various stages of physiology, with specific focus on the structure and interactions of milk protein-stabilized emulsions, using in vitro models.

Yael Vodovotz of Ohio State University said that gum disease and oral cancer have been associated with the development of systemic diseases such as diabetes, coronary heart disease, and stroke and that flavonoids in grapes and strawberries show promise in preventing oral diseases. However, much of the phytonutrients consumed from fruits shows little intrinsic activity because of poor absorption and biologic degradation. She described studies to improve biological uptake by localizing release of bioactives in the oral cavity at a desired rate. Starch confections were made with grape and strawberry with varying amounts of soy protein and water to produce products with different physicochemical and rheological characteristics. Sensory evaluation showed that despite individual differences in saliva production, differences in amorphous states of these confections resulted in differences in the duration of phytochemical deposition in the mouth.

Eyal Shimoni of Technion–Israel Institute of Technology said that since properties, digestion, and health-promoting effects of a food are affected by its three-dimensional structure, the design of this structure is at the heart of controlling all these properties. By understanding the driving forces behind these properties and their relation to food functionality, one can in principle design foods. For example, he said, using starch as a model component and structuring its crystalline polymorphism, structure, and interaction with low-molecular-weight compounds, one can tailor nutritional and physiological benefits.

Lingyun Chen of the University of Alberta in Canada said that many nutraceutical compounds have low bioavailability because of insufficient residency time, low permeability, and/or low solubility within the human gastrointestinal tract. For example, while beta-carotenoids can protect cells against oxidation to reduce the risk of cancer and other aging-related diseases, only a small proportion of the total amount found in fruits and vegetables is bioavailable. He said that nanoparticles may allow efficient delivery of nutraceuticals to the small intestine for improved absorption. He described the formation of plant protein-based nanoparticles and the impact of protein structure and particle size on their physicochemical and physiological properties.

Uri Lesmes of the University of Massachusetts described studies of food-grade emulsions as delivery systems for lipophilic ingredients, such as omega-3-rich oils, to improve their physical and chemical stability. He discussed the development of innovative delivery systems using interfacial biopolymer complexes. Lactoferrin-sodium caseinate complexes showed improved emulsion stability to pH, ionic strength, and lipid oxidation without affecting lipid digestibility by lipase, and beta-lactoglobulin-dextran complexes improved emulsion stability with slight impact on lipase digestibility.

The three-dimensional structure *of a food influences its properties, digestibility, and nutrient bioavailability and can be modified to provide targeted nutritional and physiological benefits.* Photo © iStockphoto.com/gmutlu

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Designing for Bioavailability

The symposium "Nutrient Bioavailability by Design" was also presented at the 2010 IFT Annual Meeting & Food Expo. Fabiola Dionisi of the Nestlé Research Center in Switzerland said that food technology could play an important role in modifying foods to improve absorption of nutrients with low bioavailability and to decrease absorption of nutrients with high bioavailability (e.g., fats and carbohydrates) to reduce calorie intake or sustain release in the body. Different ways are available to design bioavailability for a targeted benefit, she said, such as modifying food structure and composition to influence gut microflora transformations and modifying transport through the gut.

Since fortifying foods with iron adversely affects color, taste, and shelf life, Nestlé has developed an inorganic iron source, ferrous ammonium phosphate, that is significantly more bioavailable than ferric pyrophosphate. The white, tasteless