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# Protein-polyphenol particles for delivering structural and health functionality

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ABSTRACT

Dietary proteins and polyphenols contribute both nutritive and extra-nutritional (disease-preventing and metabolism-enhancing) benefits, *and* can participate in food structure formation and stabilization. There is a desire to increase consumption of proteins and polyphenols based on health considerations, and one approach is to form protein-polyphenol particles that combine both *health* and *structural* functionality in food products. The roles of proteins and polyphenols individually, or when bound together, are discussed in terms of health benefits (nutrition, disease prevention, satiety, allergy alleviation) and impact on food structure. The overall goal should be a rational design of protein-polyphenol particles to ensure a positive contribution to food quality, protein nutrition, and delivery of a health-relevant dose of polyphenols to the gastrointestinal tract.



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## 1. Introduction

### 1.1. Professor Glyn Phillips, a legacy of advancing the science of food hydrocolloids

In the first issue of *Food Hydrocolloids* (Phillips, Williams, &

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Wedlock, 1986), Professors Phillips, Williams, and Wedlock stated that “the scope will include areas such as chemical and structural analyses, identification in food systems, conformational studies in solution, rheological behaviour of solutions and gels, specific food applications, legislative and toxicological aspects, alternative sources and new or prospective products” related to food hydrocolloids. This reflected their collective wisdom in realizing the need for a journal to focus on the unique contributions polysaccharides and proteins provide in foods. Articles contained in the first issue mostly addressed physical/chemical properties of biopolymers, but health applications were covered in one by addressing the dietary effect of sodium carboxymethylcellulose. Professor Phillips' long career and ninetieth birthday are appropriately celebrated by highlighting some of the contributions of hydrocolloids to food structure and health – two areas he has championed. In addition to his direct contribution to science, he has mentored and inspired countless young scientists working with hydrocolloids. I (Foegeding) am honored to count myself as one whose conversations with, and encouragement from, Professor Phillips have profoundly benefited my career. Undoubtedly, he will continue to welcome the next generation of scientists into the food hydrocolloids community and serve as a source of knowledge and inspiration.

### 1.2. Health and hedonic roles of proteins and polyphenols in foods

Foods can be viewed from two distinct scientific perspectives. One considers foods as complex structures built from a collection of molecules with the sole purpose of creating enjoyment when consumed. From this point of view, hydrocolloids are building blocks used for the formation and stabilization of meso-structures (middle level) that generate texture, control release of flavor and taste compounds, and contribute to appearance. These collective attributes are part of the hedonic sensations that determine our likes or dislikes. A second point of view is that foods are a collection of molecules that provide nutrients and bioactive compounds that are beneficial, if not essential, to human health. Scientists associated with the first perspective use concepts from colloidal chemistry, soft matter physics, and food material science to understand formation and properties of food structures. Equally, health scientists strive to determine the function of individual molecules in human biology. In reality, food should conform to two overall goals – it should be enjoyable and also contribute positively to nutrition and health. Food products can therefore be considered a unique application of material science where the molecules are used for two purposes. Ingredients are assembled into a food product with the first goal of delighting the senses, and then products are disassembled post ingestion into molecules and metabolites that may have specific physiological functions in the body. This presents challenges, as optimization for one function may decrease the usefulness of the other. For example, modifying a protein to improve thermal stability in a beverage by a process that makes it indigestible defeats the nutritional goal of adding protein to a beverage. Likewise, loading a food with enough of a polyphenol to reduce inflammation is not effective if the bitterness caused by the polyphenol makes the food unpalatable. As stated by Day, Seymour, Pitts, Konczak, and Lundin (2009), “The design and development of functional foods should not be carried out purely based on the desired nutritional function without taking product properties such as colour, texture, taste and mouthfeel into account.”

Proteins and polyphenols influence hedonic and health-related properties in foods at the molecular, and at the meso-scale (Fig. 1). Proteins and polyphenols can contribute as independent molecules, where molecular structure is important to properties such as proteins binding flavor compounds (Guichard, 2006; O'Neill, 1996) and polyphenol interactions with receptors and enzymes (Murakami & Ohnishi, 2012). Due to the natural affinity of proteins for medium-polarity polyphenols, the two types of molecules can also be bound together (spontaneously or deliberately) into protein-polyphenol aggregates, henceforth referred to as *protein-polyphenol particles*. This is a long recognized and investigated phenomenon, as evidenced by a 2012 publication titled “Fifty Years of Polyphenol-Protein Complexes” (Hagerman, 2012), but only recently has this complexation been exploited by purposefully forming protein-polyphenol particles to improve food functionality. Typically, non-covalent bonding can stably combine one or more polyphenol molecules with a protein molecule, although some covalent bonding can also occur (Kroll, Rawel, & Rohn, 2003). Protein-polyphenol particles can involve a few molecules and remain at the nanometer scale, or undergo extensive aggregation and produce micrometer size particles. This review addresses the established and potential food applications of protein-polyphenol particles. It will not cover the use of proteins as encapsulation agents for polyphenols. Encapsulation as a way to protect/deliver polyphenol bioactivity has and continues to receive extensive investigation regarding factors such as encapsulation efficiency, stabilizing the encapsulated agent, and release of the encapsulated

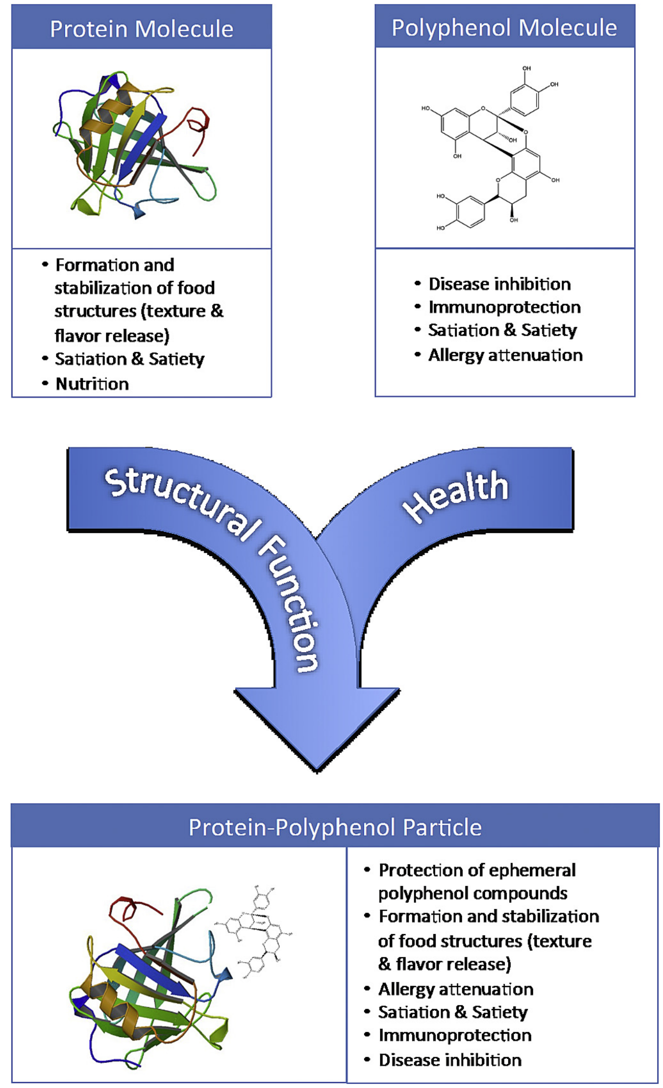


**Fig. 1.** Functions of proteins, polyphenols, and protein-polyphenol particles in foods. Structure of β-lactoglobulin is from the entry of Brownlow, S., Morais-Cabral, J.H., Sawyer, L. into the RCSB Protein Data Bank.