1 Introduction

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Antioxidants, polyunsaturated fatty acids, and proteins are common bioactives that can be added to food to improve its nutritional value and to prevent diseases such as cancer and heart disease for an improved overall health of the consumer. Bioactive stability, poor solubility in water, and low bioavailability are some of the challenges faced by the functional food industry interested in achieving optimum activity of the bioactives. It is generally accepted that nanoparticles offer distinct advantages for delivery of bioactives over traditional methods of delivery, such as improved stability, controlled release kinetics, and targeting of the bioactive for enhanced uptake and functionality of the bioactive. Nanodelivery systems, emulsions, solid lipid nanoparticles, polymeric nanoparticles, nanocomplexes, etc., are unique; their individual physical, chemical, and biological properties make them suitable for some specific food applications. No delivery system is superior above all others across the board. While the advantages of nanodelivery systems for food applications are supported by a wealth of data, the interaction of nanoparticles with the human body is complex and not fully understood. Due to their small size, nanoparticles have the potential to translocate to various parts of the body, raising concerns about their safety. The multitude of types of delivery systems and associated properties make safety assessment a challenging task for the researchers and regulatory agencies. Without compelling scientific data supporting safety of nanodelivery systems, their application in functional foods has no future, regardless of their proved beneficial impact on the functionality of the bioactive.

This book attempts to gather and present the latest data on all aspects of nanodelivery of bioactives ingredients to functional foods. It starts by describing the gastrointestinal (GI) tract and its function, with emphasis on uptake of macro- and micronutrients (Chapter 2). Nutrients can be effectively delivered by nanoparticles through two mechanisms: (i) the load is released from the delivery systems in the GI tract and absorbed by established bioactive-specific mechanisms; (ii) particles are absorbed intact and the load carried to the blood stream and cells, where the bioactive is released. Nanoparticle properties, composition, morphology, size, and surface properties among others play a key role in their interaction with biological systems. The effect of nanoparticle–cell interaction on bioactive uptake in the GI tract can be thoroughly understood by performing experimental studies accompanied by molecular dynamic simulations, as highlighted in Chapter 3.

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Several methods are available to synthesize nanoparticles of controlled properties out of biocompatible and biodegradable food-grade materials. Interfacial science is at the basis of nanoparticle formation, nanoparticle stability profiles, and release kinetics of the bioactive (Chapter 4). The process of emulsification is a key component of most nanoparticle synthesis methods, hence a thorough understanding of emulsion formations and ways to control emulsion size is provided in Chapter 5.

Various loadings, release properties, and nanoparticle stability profiles can be achieved by carefully selecting a synthesis method and associated parameters from the multitude of available processes (Chapter 6). More often than not, these properties are reported in the literature for newly synthesized nanoparticles. It is now understood that when particles are incorporated into the food or en-route through the GI tract, these properties are changed as a result of nanoparticle interaction with the food components or the media to which it is exposed. In general, methods for the detection of soft, nonmetallic nanoparticles incorporated into complex food matrixes are not readily available. Methods that are available for characterization of the nanoparticle itself or when suspended in a simple food medium include spectroscopic and microscopic technique as described in Chapter 7.

The most significant improvements that can be offered by nano-entrapment include enhanced stability and improved bioavailability of the bioactives. Chapter 8 provides an overview on the stability of bioactives entrapped in emulsions and stabilized emulsions, while Chapter 9 covers the stability of a particular bioactive folic acid, delivered with various polymeric encapsulants. Improved bioavailability of polyphenols delivered with polymeric nanoparticles is discussed in Chapter 10.

Organic, soft, nonmetallic nanodelivery systems designed for food applications are classified into two main groups: liquid (nanoemulsions, nanoliposomes, and nanopolymersomes) and solid (solid lipid nanoparticles, polymeric nanoparticles, nanocrystals, and complexes). A significant portion of the book (Chapters 11–18) is dedicated to different types of particles, emulsions, liposomes, solid lipid nanoparticles, polymeric nanoparticles, nanocomplexes, bi-continuous systems, and nanofibers, with an emphasis on synthesis methods, properties, and applications.

The type of nanoparticle, as well as physical and biological nanoparticle properties determine the route of clearance from the gastrointestinal system and possible toxic effects. Safety concerns stem from the potential of the nanoparticle to translocate to tissues due to their small size and the higher than physiological normal concentrations of the nanodelivered bioactive in this tissue. Involvement of scientists, risk assessors, and the broader public is necessary in addressing possible risks from nanotechnology for bioactive ingredient delivery (Chapter 19). If consumer attitude toward nanodelivery systems in foods is not addressed early, the technology has the risk of failing before reaching its potential. Consumer attitude must therefore be addressed to see the full potential of nano-enabled applications in foods (Chapter 20). In addition, safety assessment is needed to label a certain nanodelivery system safe under conditions of use. It is not surprising that with the wide-variety of nanodelivery systems and application significant roadblocks exist in assessing safety in a broad sense (Chapter 21). Regulatory agencies throughout the world are challenged to effectively regulate the risk of nano-enabled materials to be used as delivery systems for bioactives in functional foods (Chapter 22). The approaches are different in different countries and harmonization of regulations might be attempted in the future. It is hoped that with the evolving science, increasing consumer awareness, and recent developments in the regulatory field, nanotechnology can make a true and significant impact on the functional foods industry in the area of delivery of bioactives for improved consumer health.