Seid Mahdi Jafari

Nanoencapsulation of Food Bioactive Ingredients

Principles and Applications

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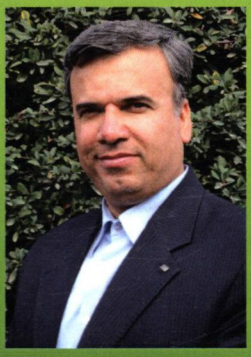
In our previous book titled *Nanoencapsulation Technologies for the Food and Nutraceutical Industries* (Elsevier, 2017), we covered the nanoencapsulation techniques applicable to the food and nutraceutical industries plus their classification to make the foundation of next studies.

This book ***Nanoencapsulation of Food Bioactive Ingredients*** presents the cutting-edge research in the field of nanoencapsulation for different food bioactive components including phenolic compounds and antioxidants, vitamins, natural food colorants, fish oil and essential fatty acids, flavors, minerals, food antimicrobial agents and essential oils, enzymes, bioactive peptides, and biological molecules. The main goal of this book is to provide recent research activities of nanoencapsulation in the food industry based on special and categorized food bioactive components.

Dr. Seid Mahdi Jafari received his PhD degree in Food Process Engineering from the University of Queensland (Australia), in 2006. He has been working on the nanoemulsification and nanoencapsulation of food ingredients for the past decade. Now, as an associate professor, he is an academic member of GAU (Iran). He has published more than 85 papers in top-ranked International Food Science journals (h-index=23) and 18 book chapters along with editing 4 books with LAP and Elsevier publishers. In November 2015, he was awarded as one of the top 1% scientists of the world with the highest citations by Thompson Reuters (Essential Scientific Indicators) in the field of Biological Sciences.



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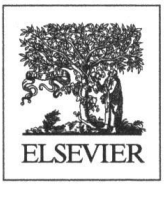

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In the Name of GOD,
The Compassionate, The Merciful

Dedication

To my beloved mother and father.
Thanks for your kindness and devotion.

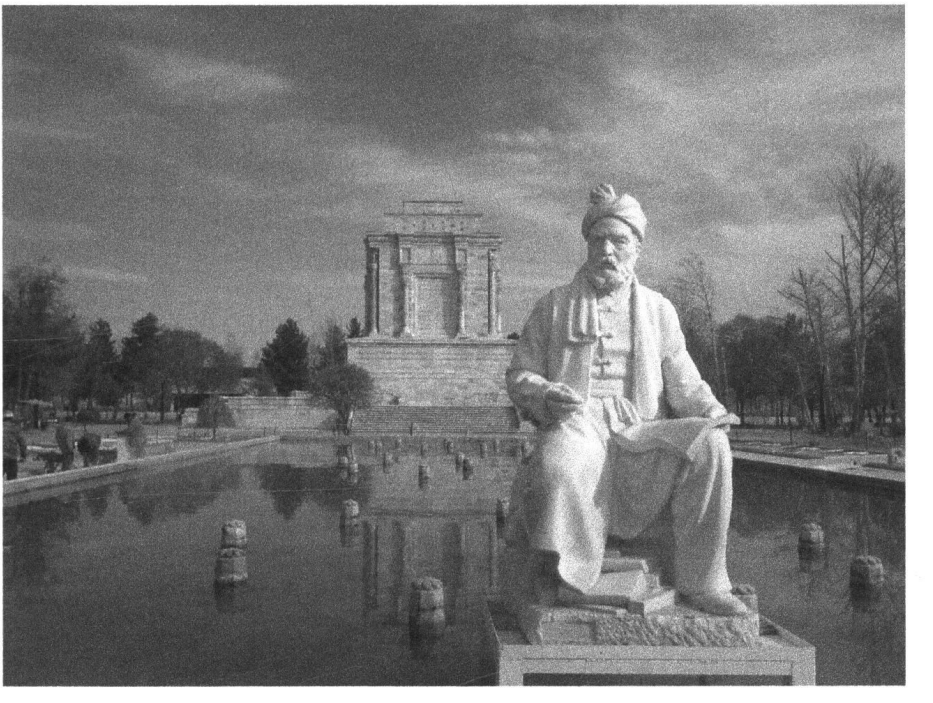
To my love, Elham and her family.
Thanks for your endless support.

To my fabulous son, AmirReza,
and my beautiful daughter, Elina.

"I am deathless, I am the eternal Lord
For I have spread the seed of the Word."

—Ferdowsi, Persian Poet (CE 935–1025)

Abu 'l-Qasim Ferdowsi Tousi, or "Ferdowsi" was a Persian poet and the author of Shahnameh (the Persian "Book of Kings"), which is the world's longest epic poem created by a single poet, and the national epic of Greater Iran and the Persian-speaking world.



Tomb of Ferdowsi and his statue, located in Tous, close to Mashhad, Northeast of Iran

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Preface

Nutraceuticals are the link between nutrition and medicine. In other words, nutraceuticals are "food ingredients that have health benefits and inhibit the advancement of diseases." Recently, the application of different nutraceutical and bioactive compounds, such as essential fatty acids (omega 3), carotenoids (β-carotene and lycopene), vitamins (D, thiamin, riboflavin), antioxidants (tocopherols, flavonoids, polyphenolic compounds), phytosterols (stigmasterol and β-sitosterol), dietary fibers (inulin), minerals (Fe^{+2}, Mg^{+2}), and bioactive peptides (casein hydrolysates) has attracted the attention of many food scientists and industries for developing enriched healthy foods and functional products. Most of the nutraceuticals are sensible to decomposition during processing and storage after being incorporated into the food structures. Bioactive compounds are typically introduced into foods using different types of encapsulation (delivery) systems. Targeted delivery is one of the most important issues in the fields of encapsulation in pharmaceutical and food science. The goal of encapsulating nutraceuticals is to reduce the damage and undesirable changes through processing stages as well as digestion conditions. Hence, developing an appropriate carrier system is quite necessary.

Nanoencapsulation is a novel and practical branch of nanotechnology in the food industry. The term nanoencapsulation describes encapsulation on the nanometer scale using biopolymers, films, layers, or nanodispersions. The final capsule acts as a nanoscale shield for the food or nutraceutical molecules/ingredients. Often the bioactive ingredient is in the molecule or nanoscale state. The major benefit is the induced homogeneity, leading to better encapsulation efficiency in addition to the improved physical and chemical properties. Nanoencapsulation is flourishing with a rapid pace in the food sector. In fact, it is possible to fabricate valued-added food products by employing the nanoencapsulation technology in the field of food and nutritional sciences. Many comprehensive studies have focused on the application of nanoencapsulation in different aspects of the food industry, such as enhancing the public health, supporting the safety of food products, and designing the principles for the delivery of nutrients.

Hence, a practical means to develop the fabrication of functional foods is the process of nanoencapsulating sensitive food bioactive ingredients. Encapsulated ingredients can be formulated in a way to withstand the

physical stresses in the digestive tract and deliver their payloads in a special site. Considering the semisolid and nonsolid food products, the reduction in the size of their network modifies their encapsulation potency without leaving any change in the sensory properties. Besides, by reaching the nanoscale, highly controllable biochemical vehicles are obtained. Meanwhile, the delivery rate scales directly with the particle size. Throughout the body, specific types of cells can absorb submicron nanoparticles more efficiently. Larger particles tend to release their bioactive molecules more slowly and over longer time periods. In addition, the size reduction in the particles elevates the bio-adhesive properties due to the increase in surface to volume ratio, which lastly heightens the bioavailability of the bioactive molecules by the prolonged transfer through the gastrointestinal tract.

In our previous book titled "*Nanoencapsulation Technologies for the Food and Nutraceutical Industries*" (Elsevier, 2017), we covered the nanoencapsulation techniques applicable to the food and nutraceutical industries plus their classification to make the foundation of next studies. In the mentioned book for the first time, we have classified nanoencapsulation technologies into five groups based on the main mechanism/ingredient, which is being used to make nanocapsules. They include lipid-based formulations (nanoemulsions, nanoliposomes, nanostructured lipid carriers), natural nanocarriers (caseins, cyclodextrins, nanocrystals), nanocarriers made with specialized equipment (electrospinning, electrospraying, nano spray dryer), bio-polymeric nanoparticles (individual protein and polysaccahride nanoparticles, their complexes), and miscellaneous techniques.

This book presents the cutting-edge research in the field of nanoencapsulation, which has been applied for different food bioactive components. The main goal of the present book has been providing recent research activities of nanoencapsulation in the food industry based on special and categorized food bioactive components. After giving an overview of nanoencapsulation techniques in the food sector (Chapter 1), we have discussed nanoencapsulation of phenolic compounds and antioxidants (Chapter 2), fish oil and essential fatty acids (Chapter 3), vitamins (Chapter 4), food antimicrobial agents and essential oils (Chapter 5), natural food colorants (Chapter 6), flavors (Chapter 7), enzymes, bioactive peptides, and biological molecules (Chapter 8), and minerals (Chapter 9). Finally, in Chapter 10, release, characterization, and safety of nanoencapsulated food ingredients have been presented.

This book would be useful for a diverse group of readers including food technologists, food engineers, nanotechnologists, nutritionists, food colloid experts, pharmacists, cosmetic experts, physicists, chemists, microbiologists, biotechnologists, and those who are interested in novel technologies in the area of food formulations, functional foods, and nutraceutical delivery systems.