CHAPTER 1

Introduction

1.1 Historical Background

Carotenoids are one of the most significant natural food colorant produced by plants, algae, fungi and photosynthetic bacteria. Carotenoids are lipophilic compounds that generate the yellow, orange, and red colors (Mortensen, 2006). The molecule consist of 3 to 13 conjugated double bonds and in some cases 6 carbon ring structures at one or both ends of the molecule. The most common carotenoids types are β-carotene, lycopene, lutein, and zeaxanthin (McClements *et al.*, 2009).

Beside their colorant property, carotenoids are source of vitamin A and precursor of important compounds responsible for the flavor of foods and the fragrance of flowers. Many recent researchers have demonstrated that carotenoids have important biologic activities associated with antioxidant property. This property can be beneficial for human health by strengthening the immune system. Carotenoids could protect and/or prevent against several harmful illnesses, such as, cancer, cardiovascular disease, macular degeneration and cataracts (Albanes, 1999; Erhardt *et al*., 2003; Man and Tan, 2003). Nevertheless, carotenoids can be easily degraded by several factors including high temperature, solvent, acid, light, free radicals, iron and iodine, electron transfer, hydrogen abstraction, adduct formation and oxygen (Boon *et al.*, 2010). To increase shelf life of the carotenoids, some protective materials have been recently studied as the encapsulated matrixes such as arabinogalactan and chitosan. The complex matrix can protect carotenoids from the oxidative degradation, thus, improving the stability of carotenoids (Polyakov *et* *al.*, 2008). However, the increasing dissolution rate of these lipophilic compounds in the water system that are common used in several food products is still required to be investigated

Chitosan and its derivatives have been known as the naturally originating polycationic polysaccharide performed by glucosamine and N-acetyl-glucosamine. They have been widely studied for applications in food, agriculture, biochemistry, cosmetic, pharmaceutical industries and wastewater treatment because they are promptly available via cationic polyelectrolyte in acid solution. Furthermore, they are the multipurpose and environmentally friendly raw material, non-toxic, biocompatible and biodegradable (Harish-Prashanthand and Tharanathan, 2007; Rinaudo, 2006). The form of the chitosan biopolymer could be liquid crystals, membranes and microcapsules.

Recently, the studies have focused on preparing the chitosan nanoparticles (Kafshgari *et al.*, 2011; Qi *et al.*, 2004) due to some drawbacks of chitosan such as poor releasing capability, poor solubility in water and limited adsorbing property. These drawbacks could be improved by decreasing the particle size. The chitosan nanoparticles exhibit superior activity as a result of their small and quantum size effect. The ionic gelation is one of many methods used to prepare chitosan nanoparticles by crosslinking process with chemical agents as it is a simple and mild method (Tsai *et al.*, 2008).

Solubility of carotenoids could be achieved by modifying the structure of the carotenoids encapsulated chitosan with the crosslinking agent such as tripolyphosphate (TPP). Chitosan has a high density of amine groups in its backbone and the amine groups are protonized to form NH_3^+ in acidic solution. These positively charged groups in chitosan can be chemically cross-linked with TPP.

TPP is a non-toxic, biocompatible and biodegradable (Muzzarelli, 2009) that has been recognized as an acceptable food additive by the US Food and Drug Administration (Lin *et al.*, 2008). The quick gelling ability of TPP is the important properties that make it a favorable cross-linker for ionic gelation of chitosan (Gan and Wang, 2007). The amine groups of chitosan are protonated, which can interact with the anionic TPP through electrostatic attraction and are transformed into the chitosan–TPP gel (Lee *et al*., 2001; Mi *et al.*, 2003)**.** Nonetheless**,** the previous studies have investigated the properties of this chitosan derivative on the drug entrapment efficiency and drug release behavior (Gupta and Jabrail, 2007).

According to the polar properties of the chitosan–TPP matrixes, carotenoids encapsulated in the chitosan–TPP nanoparticles could have the desired properties of increasing water solubility and prolonging shelf life. These modified properties would benefit several food industrial applications. Significantly, the process of ionic gelation of chitosan with TPP is feasible for the scale-up in a particle processing operation (Stulzer *et al.*, 2009).

The limitations of poor releasing capability, poor solubility in water and short shelf life of carotenoids highlight how it is important to have a critical understanding of the preparation of chitosan–TPP matrixes so that technologies can be developed to optimize these detrimental aspects. The main purposes of this work were to determine the effects of TPP on encapsulation of carotenoids in chitosan at various ratios of carotenoids to TPP. The general properties such as encapsulating efficiencies, particle appearances, and area fraction of the porosity, color, solubility and stability of the chitosan nanoparticles were determined. The selected encapsulated sample was verified as the natural colorants for salad cream and commercial drink.

1.2 The Scope and Aims of This Research

To improve the limitations of poor releasing capability, poor solubility in water and short shelf life of carotenoids, the chitosan–TPP matrix was developed to ameliorate one or more of the disadvantages described above. The aims of this research work were to:

1.2.1 examine the optimal carotenoids and TPP quantities on the preparation for encapsulation of carotenoids,

1.2.2 determine the physical characteristic including particles size, color, solubility, and encapsulation efficiencies of the carotenoids encapsulated in chitosan, 1.2.3 examine the chemical characteristic of the selected carotenoids encapsulated in chitosan by the Fourier Transform Infrared Spectrometer (FT-IR),

1.2.4 investigate the releasing and antioxidant properties of the selected carotenoids encapsulated in chitosan,

1.2.5 evaluate the storage stability of the selected carotenoids encapsulated in chitosan, and

1.2.6 study the application of the carotenoids encapsulated in chitosan as food colorants in salad cream and commercial drink.