CHAPTER 5

Conclusion

The detrimental aspects of poor releasing capability, poor solubility in water and short shelf life of carotenoids could be optimized by encapsulation of carotenoids in the chitosan–TPP matrixes. The optimal condition for preparing the chitosan–TPP was 3.0% (w/v) of carotenoids solution, 1.5% (w/v) chitosan and 2.0% (w/v) TPP. The encapsulation efficiency of carotenoids in chitosan–TPP was increased with increasing TPP quantity, while the highest efficiency of 89.09% of the optimal formula was obtained within 36 hr of encapsulation.

The carotenoids encapsulated in chitosan–TPP observed under the SEM appeared an irregular shape and rough surfaces with mean diameter of 230-500 nm. Addition of TPP could significantly ($P \leq 0.05$) decrease the particles size of the particles as well as the interstitial pore fraction of the encapsulated carotenoids.

The color study indicated that the encapsulation efficiency could be observed on the values of a* and b* and these values increased with increasing amount of TPP in the matrix.

The solubility results obtained from the ethanol and water systems revealed that the solubility tended to vary with the particle size of encapsulated carotenoids. The smaller size that obtained from adding higher amount of TPP increased the solubility significantly ($P \leq 0.05$). Although dissolving of the encapsulated carotenoids in water, 53.65-63.42%, was less than those in ethanol, 68.51-78.56%, the chitosan-TPP could improve the solubility of carotenoids in water effectively.

The FT-IR spectrum showed that carotenoids consisted ofthe C=O of carbonyl group, C-H of aliphatic and conjugated phenol group, while chitosan consisted of the CH_3groups, amide I groups, N–H, C–O of the primary alcoholic groups, amide II group and C-O-C groups. The FT-IR spectrumof the carotenoids in the chitosan without TPPwas shifted from 1541 $cm^{-1}$to 1545 $cm^{-1}$when the 2.0% (w/v) TPP was used as the result of the crosslinking between the phosphoric group of TPP and ammonium group of chitosan.

The releasing properties of carotenoids encapsulated chitosan-TPP was tested in coconut oil, ethanol and phosphate bufferat pH 7.4 and it was found that the release of carotenoids in coconut oil were greater than those in ethanol and phosphate buffer significantly ($P \leq 0.05$).

The stability study showed that degradation of the encapsulated carotenoids wasthe first order kinetic during storage at 5, 25, or 40°C for 60 days. The degradation rate constants (*k*) were increased withthe increasing storage temperature while the half-life values were decreased withthe increasing temperature. The Arrhenius and thermodynamic parameters for encapsulated carotenoids revealed that the activation energy (E_a) was 20.66 kJ/mol, the enthalpy of activation ($\Delta H\neq$) was 18.21 kJ/mol and the entropy of activation ($\Delta S\neq$) was -219.49 J/mol. Correspondingly, the degradation of antioxidant capacityand color values followed the first order kinetic.The degradation rate constants (*k*) of oxidation and color values were increased with increasing temperature.

The encapsulated carotenoids has satisfactory releasing capability and solubility in both aqueous and lipid systems. Applications of the encapsulated carotenoids in salad cream and commercial drink suggested that the developed carotenoids could be successfully used as the natural colorant for food products.

Suggestions for the future works:

Releasing of this developed carotenoids encapsulate was 5 hr which might be too long for some industrial applications. The shorter releasing time and the sensory test should be considered in the future work.