CHAPTER VI

Overall Conclusion

In this research, the development of surimi gel and effect of gel structures on oil uptake and other frying characteristics of surimi gels were studied.

The two heating steps in surimi gel preparation are heat setting at low temperature (35-50 °C for threadfin bream surimi and 35-80 °C for cod surimi) and cooking at 90 °C. Different gel strength samples can be obtained from different heat setting time-temperature combination.

The change of gel strength involves two reactions namely, gel forming (enhancing by transglutaminase enzyme) and gel breakdown (through proteolysis) are network that follow a competitive-consecutive first order model. Kinetic parameters, obtained from an isothermal model, can be used to explain the relation between gel strength and time at any temperature and determine the optimum setting time that provide the maximum gel strength at any setting temperature.

Different setting time-temperature also give different network. Higher gel strengths are obtained from higher solid fraction gels and higher density of network fibres. The change in gel strength correlates with the network structure including void and solid fraction. Thus, surimi gel with different structure can be obtained by varying strength of the gels.

The effect of gel structure on frying characteristics of surimi gel was observed. Gel structure affects kinetics of oil uptake, crust formation, water removal and heat transfer inside the gel block during frying. The kinetics of oil uptake in surimi gels was distinguished between surface oil (fraction of oil that remains on the surface) and structural oil (absorbed during frying or during frying and cooling period).

Small amount of oil was absorbed during frying while large quantity was picked up after removal of the gel from hot oil. During cooling, oil was located either on the surface of the gel or suctioned into the gel. More than 80% of total structural oil uptake occurred within the first minutes of cooling.

The relationship between gel strength and crust formation during frying crucially affected oil uptake and moisture loss. Higher initial gel strength provided product with higher crust strength and limited quantities of water loss and oil penetration both during frying and cooling. Oil uptake and moisture loss decreased as gel strength increased. As a result, gel strength and structure significantly affect oil uptake and water loss of gel.

A low permeability crust restricted the rate of steam escape. The high steam pressure inside the gel during frying resulted in the internal gel structure breakdown. The voids occurred and were full filled with steam. The heat pipe-like-heat transfer was evidenced. A mathematical heat conduction model of infinite cylinder system with stepping change of thermal conductivity was developed to predict the temperature distribution in surimi gel. The model developed to predict temperature distribution inside the gel during frying at 180 °C for 3 minutes is in good agreement with experimental data.

Overall, heat setting time-temperature combination is the main factor affecting surimi gel development. Different gel structures markedly affect oil uptake and water removal during frying and cooling. The elastic crust developed on surimi gel is a special phenomenon that allows the heat pipe-like-heat transfer to occur during frying and leads to the two stages of thermal conductivity inside the gel.

A further study that can be derived from this research is the linkage between microstructure of surimi gel and transport phenomena which occurs during frying.

This relationship is specially important for food systems. However, it is very complex and most of the transformations occur at an invisible micro-scale level. In addition, the mathematical two-stage model can also be further improved and points to features which would need to be accounted for in developing a predictive model like that for other frying foods.