CHAPTER 5

Conclusion

In conclusion, Coffee pulp was turned into active packaging by extracting pectin and chlorogenic acids as crude extract, transforming its cellulose to CMC and combining coffee pulp extract and CMC with polyelectrolyte complex structure using chitosan as a reinforcing agent and glycerol as a plasticizer. All production processes including pectin and chlorogenic extraction, CMC synthesis and film formulation were optimized. The resulting coffee pulp film was studied and verified for its active properties, such as antimicrobial activity, antioxidant activity and biodegradability. Finally, its application as active food packaging was also tested by using fresh cut carrot as a model for study.

For pectin and chlorogenic acid extraction process, process parameter including hydrochloric acid concentration, temperature and time were studied. As a result, pectin yield increased by an increase in all process variables. The DE of pectin was decreased by longer extraction time and stronger acid concentration. Meanwhile, chlorogenic acid content increased by temperature reaching 60°C or 90°C (because chlorogenic acids are membrane bounded polyphenols), but decreased by higher acid concentration. Based on the model, the yield of pectin can be improved with higher temperature, longer extracting time and stronger acid concentration; while the yield of chlorogenic acid can be improved by reducing acid concentration, lessening extraction temperature to less than 60°C or increasing it to more than 90°C. Therefore, to improve the yield on both chlorogenic acids and pectin, an increase of extraction temperature higher than 90°C is recommended. The optimum condition in extracting pectin and chlorogenic acids in this research was at 0.04 M HCl concentration, 90°C and 60 minutes.

Study of CMC synthesis process involved the effect of NaOH concentration on the yield and DS of CMC. The results showed that both yield and DS of CMC from coffee pulp was increased along the increase of NaOH concentration, because the more

NaOH concentration, the more cellulose molecules were opened up for etherification. Both values increased until the optimum condition was reached at 34% NaOH concentration resulted in° maximum CMC yield and DS. After that, more NaOH would promote the side reaction producing sodium glycolate; thus both yield and DS were decreased.

Film formulation study showed the effect of 3 film compositions; CMC, chitosan and glycerol on the mechanical properties and WVT. Film formulation with higher amount of CMC showed lower tensile strength, higher elongation at break and WVT. Meanwhile, increasing the amount of chitosan in the formulation increased tensile strength and water resistance of the film, but reduced film flexibility due to the reinforcing effect of polyelectrolyte complex. However, the addition of chitosan more than 10% in the film formulation would result in more brittle film with less resistance to water as the stability of polyelectrolyte complex was compromised. As a hydrophilic plasticizer, increasing amount of glycerol would promote film flexibility (higher elongation at break) as well as WVT of the film. Yet, at high portion, glycerol would decrease the film elongation due to the reduced film cohesiveness. As a result, the film formulation with highest tensile strength and water resistance (lowest WVT) with moderate film flexibility was comprised of 70% CMC, 10% chitosan and 20% glycerol.

The film with polyelectrolyte complex showed double in tensile strength, half the rate of water transmission and less soluble in water while being more hydrophilic than the CMC film. The presence of polyelectrolyte complex structure was shown by SEM micrographs, increasing hydrophilicity and the blue shift of carbonyl and hydroxyl groups in FT-IR spectrums.

Coffee pulp film showed excellence degradability under composting condition. Though, the film only showed slight antimicrobial activity against gram positive bacteria such as *Staphylococcus aureus*, its potent antioxidant activity made it possible for active packaging application. Therefore, fresh cut carrot was chosen as a model for this demonstration. Coffee pulp initially showed better performance in preventing color degradation of fresh cut carrot than the conventional packaging (polypropylene tray wrapped with polyvinyl chloride cling film). However, its poor moisture barriers led to severe moisture loss and inferior microbiological control. Thus, according to microbiological criteria (8 log CFU/g), shelf life of fresh cut carrot wrapped with coffee pulp film was only 2 days, when the conventional packaging was 4 days. The main reasons for inferior performance were film hydrophilicity and possible degradation of chlorogenic acid which acted as active compound in the film. Nevertheless, the enhanced film hydrophilicity and antioxidant activity would make coffee pulp film a good moisture absorber that can also provide active property of an antioxidant. Those benefits would enable coffee pulp film to be used as inner liner or inner packaging or edible coating of snacks, nuts, fried and bakery products that deteriorated by moisture gain and rancidity from oxidation process.

This research portrayed the use of all solid mass of a major agricultural waste; liked coffee pulp. Most constitutions were utilized and turned into active packaging. Though, the cost is high and its performance was still less effective than conventional packaging. With further research and development on the film structure, control release system and stability of active compound like chlorogenic acid, coffee pulp film could provide an environmental friendly alternative for active food packaging.