CHAPTER 7 CONCLUSIONS AND RECOMMENDATION

7.1 Conclusions

The evolutions of the phytochemicals in outer leaves of cabbage during production of DF powder were investigated. The phytochemicals of interest were phenolic compounds, vitamin C, β-carotene, α-tocopherol glucosinolates and sulforaphane. The work done in this dissertation included determining the effects of processing on antioxidants and glucosinolates. The effects of processing steps on evolution of sulforaphane, an derivative of glucosinolates, during drying was conducted. The feasibility of using microwave extraction to sulforaphane from white cabbage was also determined.

In Chapter 3 the experiments were performed to determine the effects of preparation and blanching methods as well as drying conditions and methods, on the evolutions of major antioxidants in cabbage outer leaves. Although processing steps and blanching methods did not have any significant effect on the DF compositions, these procedures had marked effect on the antioxidant content. Slicing cabbage leaves prior to blanching caused higher losses of water-soluble antioxidants, i.e., phenolic compounds and vitamin C. No changes in β-carotene and α-tocopherol, which are lipid-soluble vitamins, were observed during blanching. Steam blanching could provide better retention of phytochemicals due to shorter blanching time and less loss of water-soluble antioxidants into the blanching medium. The losses in phytochemicals and their activities occurred mostly during drying. Dried unblanched samples exhibited higher losses of phytochemicals than dried blanched ones. Losses of antioxidants during vacuum drying were also noted to be less than those during hot air drying.

To extend the work from Chapter 3, the effects of processing steps, i.e., slicing, blanching and drying, on the changes of glucosinolates, an anticarcinogenic substance, in cabbage outer leaves were investigated in Chapter 4 along with the changes of other basic properties of DF powder. The results showed that slicing cabbage leaves prior to blanching led to higher losses of glucosinolates, while steam blanching provided better retention of glucosinolates due to shorter blanching time and lower losses of glucosinolates into blanching water. Glucosinolates retained in the treated leaves lost further during hot air drying than during vacuum drying; the drying temperature did not have a significant effect on the quality of the DF powder, however. By considering the whole process steam blanching the whole leaves of cabbage and then slicing prior to vacuum drying at 80°C is recommended for the production of high DF powder from cabbage outer leaves.

The evolution of sulforaphane during preparation and drying was determined in Chapter 5. It was evident that drying temperature had a significant effect on both the formation and degradation rates of sulforaphane during drying. A semi-empirical heat transfer and kinetic model was proposed to describe the change of sulforaphane throughout the drying process and it was found to give excellent fit to the experimental data. The amount of sulforaphane during drying at 40 °C gradually increased and reached a constant toward the end of drying process. In the case of drying at 50-70 °C, sulforaphane first increased and reached the highest values, then gradually decreased. The maximum sulforaphane content was the range of 2.39-2.43 mg/100 g dry weight. The hot air drying process may be stopped when the sulforaphane content is at a maximum level; sulforaphane can then be extracted at that maximum point.

The feasibility of using microwave extraction to extract sulforaphane was also performed in Chapter 6. The results showed that MAE is more effective than conventional extraction as it exhibited higher yield of sulforaphane in much shorter extraction time. Higher microwave power resulted in shorter time to reach the maximum yield of sulforaphane. There was no difference for the highest extraction yield obtained from the fresh and semi-dried samples. The results also showed that the use of different solvents did not have any effect on enhancement factor of either fresh or semi-dried sample. The suggested extraction condition was MAE of sulforaphane from fresh cabbage at 390 W using water as solvent.

Overall, the present work showed that there is a potential to produce high DF powder from cabbage outer leaves that still contains health beneficial antioxidants and anticarcinogenic substances via the suggested production process. Another possible way to add value to the cabbage outer leaves is to use this by-product as a starting raw material to produce the sulforaphane extract. This anticarcinogenic substance can be formed during microwaving before being extracted in the same system, hence reducing the whole process time.

7.2 Contributions to Knowledge

Regarding the results obtained in this study, the following contributions to knowledge are made:

7.2.1 Phenolic compounds and vitamin C are major antioxidants found in white cabbage outer leaves while β-carotene and α-tocopherol presented in small amounts.

7.2.2 Preparation steps, i.e., blanching and slicing, did not lead to any significant changes of the DF powder compositions.

7.2.3 The degradation of glucosinolates during drying occurred when the sample temperature was above 60 °C.

7.2.4 Vacuum drying provided the DF powder with higher retention of antioxidants as well as glucosinolates.

7.2.5 Sulforaphane is much more heat sensitive than glucosinolates.

7.2.6 The formation and degradation of sulforaphane occurs during drying at 40-70 °C. The sulforaphane formation occurred when the cabbage temperature during drying was in the range of 25-53.5 °C and thermal degradation took place once the cabbage temperature exceeded this range.

7.2.7 Drying temperature is the most important factor controlling the rate of formation and degradation of sulforaphane.

7.2.8 Microwave extraction provided higher extraction yields of sulforaphane in much shorter extraction time than conventional method.

7.2.9 Sulforaphane could be formed during the microwave extraction when the sample temperature was less than 55 °C

7.3 Recommendation

The present work has demonstrated that there is a potential to produce the DF powder from cabbage outer leaves. This newly developed product still associated with high antioxidant and anticarcinogenics activity. However, information on bioassessibility and bioavailability of DF powder both *in vitro* and *in vivo* as well as toxicological testing is required prior to produce commercially. Studies on physical and functional properties of DF powder and application of the powder as a food ingredient are also suggested as future works.

In addition of production of DF powder from cabbage outer leaves, the crude extract of sulforaphane could be obtain via the use of MAE successfully. Further studies on the purification as well as stability of the extract are recommended.