CHAPTER 4

CONCLUSION

The results of the carried out work can be summarized as follows:

1. Turmeric and zedoary rhizomes harvested at 6-month-old contain the highest amounts of curcuminoids and volatile oil.

2. Curcuminoids content in turmeric rhizome did not decrease over the 15 months storage period, irrespective of whether the turmeric rhizome was prepared as slices or powders, or whether the preparations were stored in black polyethylene or paper bags. However, zedoary (bulb and finger) rhizomes lose significant amounts of curcuminoids on storage. The data suggested that zedoary rhizomes should be prepared as slices (rather than powders) and stored in black polyethylene bags to better maintain total curcuminoids. Volatile oil content of turmeric and zedoary rhizomes stored in black polyethylene bags was higher than that of rhizomes stored in paper bags. Furthermore, preparation forms of turmeric and zedoary (slices or powders) also affected volatile oil content. Rhizomes prepared as slices have a higher volatile oil content than that prepared as powders.

Qualitative difference could be observed in GC-MS profiles of volatile oil obtained from turmeric and zedoary rhizomes during different storage periods. The major constituent of volatile oil obtained from turmeric and zedoary rhizomes

before storage (zero time) was ar-turmerone, and those after 6 and 12 months storage was β-turmerone.

The result from stability studies to predict the shelf-life of curcuminoids of turmeric and zedoary rhizomes, sustainable time of storage may be effectively applied to preserve the curcuminoids content. The degradation of curcuminoids of turmeric and zedoary rhizomes submitted to accelerated temperatures was observed to follow first order kinetics. The predicted shelf-life ($t_{90\%}$) of curcuminoids content of sliced turmeric rhizome stored in black polyethylene and paper bags at room temperature were both about 2.5 years, while $t_{90\%}$ of those of powdered rhizome stored in black polyethylene and paper bags were 2.3 and 1.7 years, respectively. However, $t_{90\%}$ of curcuminoids content of sliced and powdered zedoary (bulb) and zedoary (finger) rhizomes were about 0.2 and 0.4 year, respectively.

The active constituents of turmeric and zedoary rhizomes (curcuminoids and volatile oil) are sensitive to environmental conditions including temperature, light, humidity and oxygen. It is therefore important to know any information concerning the factors affecting the stability of those active components.

Normally after harvesting, turmeric and zedoary rhizomes are prepared in various forms such as powdered, sliced and whole rhizomes, and stored in different types of containers for example in paper bags, in transparent containers or in black polyethylene bags. However, little information is available on the effect of the storage conditions on the content of the active constituents and their biological activities. The result from this present study indicated that turmeric and zedoary

rhizomes prepared in sliced form and stored in black polyethylene bags could maintain their active compounds better than those prepared in powdered form and stored in paper bags. The results may be useful and provide information for the industrial production, scientists, traditional healers and consumers in order to make decision with regards to keeping and prescribing process and storage condition of the turmeric and zedoary rhizomes.

3. The increase in storage periods of turmeric and zedoary rhizomes results in a decrease in antioxidant and antibacterial activities. The increase in storage periods showed differences in IC_{50} values of turmeric and zedoary extracts (higher IC_{50} values on longer storage), and MIC of all extracts after 12 months storage was higher than those before and after 6 months storage of these rhizomes.

The decline in antioxidant activity may be due to the decrease in volatile oil content of turmeric, zedoary (bulb) and zedoary (finger) rhizomes and the decrease in curcuminoids content of zedoary (bulb) and zedoary (finger) rhizome at different storage periods. Antioxidant activity and volatile oil content of turmeric rhizome relationships (Appendix A, Figure A-33) deduced from results demonstrated that the decrease in antioxidant activity of turmeric rhizomes after 12 months storage (about 30 %) is related to the loss of volatile oil content (about 17 %). It has been noted that the antioxidant activity of zedoary (bulb) and zedoary (finger) rhizomes is due to synergy between curcuminoids and volatile oil contents. Relationship between antioxidant activity and curcuminoids content; and between antioxidant activity and volatile oil content of zedoary (bulb) rhizome (Apendix A, Figures A-34 and A-35, respectively) indicated that the decrease in

antioxidant activity after 12 months storage (about 24 %) is correlated to the decrease in the content of curcuminoids (21 %) as well as volatile oil (36 %). In the case of zedoary (finger) rhizome, relationships between antioxidant activity and curcuminoids content; and between antioxidant activity and volatile oil content (Appendix A, Figures A-36 and A-37, respectively) demonstrated that the decrease in antioxidant activity after 12 months storage (about 28 %) is related to the decrease in the content of curcuminoids (about 20 %) and volatile oil (about 27 %).

The antibacterial activity of turmeric, zedoary (bulb) and zedoary (finger) rhizomes seems to decrease with increasing of storage periods. These might be presumed to be due to the different in volatile oil content of these rhizomes stored at different storage periods. The relationship between antibacterial activity and volatile oil content of turmeric, zedoary (bulb) and zedoary (finger) rhizomes are shown in Apendix A, Figures A-38, A-39 and A-40, respectively).

Turmeric and zedoary could be effectively used in the treatment of bacterial infection, such as diarrhea and skin problems, and diseases-related oxidative stress, such as inflammation, cancer and aging. However, after many years of storage these plants may no longer be effective for the treatment of these diseases because of lossing active components.

In conclusion, to preserve the best quality of turmeric and zedoary rhizomes for the most effective source of active constituents in the materials, we suggested that the turmeric and zedoary rhizomes should be harvested after 6 month olds.

After clean and wash, they should be cut into slices, dried and kept in black polyethylene bags in dry place away from light. When needed, the sliced rhizomes will be taken and powdered before use.

Further studies are needed to determine the best storage conditions to preserve the curcuminoids and volatile oil contents of turmeric and zedoary rhizomes. Studies are also needed to verify the storage conditions on the content of individual curcuminoids (curcumin, demethoxycurcumin and bisdemethoxycurcumin) of turmeric and zedoary rhizomes. Moreover, further studies are required to assess the effect of storage of turmeric and zedoary rhizomes on other biological activities, such as antitumor and antiinflammatory activities. The methodology developed in the present study, and the preliminary data generated therein, will hopefully help in the design and implimentation of these studies in the future.