CHAPTER 8

Conclusions

Firstly, this research aimed to screen selected Thai aromatic plants that provided preferable aroma toward consumer with antioxidant activity. White champaca(*Michelia alba* D.C.: MAD) was the most preferable Thai aromatic plants which showed potential for product development using aroma and flavor based on consumer preference with high antioxidant activity. Secondly, The MAD was captivated to dry and ground before taken to extraction. Crude extract was prepared for flavor encapsulation using octenyl succinic anhydride starch (OSA starch). Thirdly, the characteristic aromas were identified using gas chromatography and sensory descriptive analysis. Fourthly, the MAD extract was taken to prepare for microencapsulation using OSA starch as wall material. The optimization of the MAD extract and OSA starch was established. Fifthly, the MAD encapsulated flavor powder was introduced into gelatin-gum arabic system (GGA system) which infuse with the pandan flavor to create the multi-core flavor encapsulated flavor powder with controlled release properties. The optimization of the gelatin, gum arabic, and the pandan flavor were also proven to be possessed control-release property. Finally, the multi-coreencapsulated flavor powder was applied into Thai steamed dessert: Nam Dok Mai (NDM) to study the suitable content of the multi-core encapsulated flavor powder that provided the most preferable sensory evaluation from consumer. The most preferable formula of NDM was studied for release profile of aroma and flavor by sensory descriptive analysis using time-intensity method. All of the conclusions were presented in this Chapter.

8.1 Conclusions

Preliminary, the screening of Thai aromatic plants results suggested that Thai aromatic plants extract had unique and interesting aroma. The yield recovery of Indian cork flower was the highest (39.25%) followed bywhite champaca petals (22.83%) whereas the reducing ability power exhibited the highest rate (4.971±0.015 mmol/g sample) and DPPH scavenging activity (72.12). The consumer acceptance showed that kaffir lime leaves, champaca petals, and white champaca petals had high overall aroma rating at 6.6±0.04, 6.5±0.03 and 6.3±0.03, respectively with significant difference. The selected plants extract were provided dominant characteristic odor of citrus and sweet (kaffir lime leaves), champaca flower/incent-like and honey (champaca petals), and white champaca flower (white champaca petals). The characteristic odors of citrus, floral, and sweet were the characters that affected consumer preference. Fifty-five volatile compounds from three selected plant were identified. Kaffir lime leaves showed high amount of menthoglycol whereas champaca petals showed high amount of beta-elemene and trans-caryophyllene which were different from white champaca petals that showed high amount of 2-methyl butyric acid and linalool. The results tended to show that white champaca petals provide potential for product development using aroma and flavor based on consumer preference with high antioxidant activity which can be further developed into food and non-food products.

Secondly, the OSA starch was selected to be wall material in the MAD extract encapsulation. The findings of this experiment revealed that the OSA starch concentration starch for encapsulation had affected on the pasting properties.The degree of changes in pasting properties of OSA starch depended on the increasing quantity ofOSA starch. However, the suitable amount of OSAfor this study was 1000 g per 1000 ml of water that starch did not becomeover retrogradation. Thus, the selected OSA starch range was 250–1000 g per 1000 ml of water that used in microencapsulation of MAD extract.

Processes of encapsulation were compared between spray drying and freeze drying. The results from this part of experiments revealed that the yield recovery of spray drying microencapsulation was lower than freeze drying at 22.42% and 50.01%. Therefore, the microencapsulation efficiency of the spray drying was higher than freeze drying at 92.62% and 66.74%. In addition, the moisture content, water activity and solubility of spray drying were lower which indicated higher stability. The change of microstructure, including color value and surface content from different drying method, serves as indicators for stability of encapsulated powder. All inclusive, spray drying produced powder with superior properties and exhibited better protection towards the core materials. Moreover, the aroma intensity of MAD encapsulated powder supported the spray dry process that can retain aroma by showing decreasing aroma intensity of main characteristic from MAD.

Thirdly, the change of the volatile compounds of MAD from fresh, dry, extract, and encapsulated powder was studied, also to evaluated the changes of main aroma characteristics. The static head space technique was used to analyze the volatile compounds. The descriptive sensory analysis was used to evaluate the characteristic aromas. There were 9 identified volatile compounds from which were 2-methyl butanoic acid, terpinolene, diethyl malonate, phenyl ethyl alcohol, lilac aldehyde, linalool, verbenone, terpendiol, and menthoglycol. All four samples showed significant difference in relative content. The characteristic aromas of MAD were floral, spice, and citrus in order of perception, respectively. Those were identified as linalool, verbenone, and 2-methyl butanoic acid. This experiment suggested that MAD flower possessed three characteristic aromas. The descriptive sensory analysis using showed that there was fluctuation of aroma intensity to be decreased along the process. Regardless of the decreasing of aroma intensity, the MAD encapsulated powder from spray drying also demonstrated potential to retain aroma by showing the decreased aroma intensity of main characteristic from MAD.

Fourthly, the optimization of microencapsulation of the MAD extract in the OSA starch by response surface methodology indicated that spray dried microcapsules that provided highest in yield recovery, encapsulation efficiency, linalool aroma release, 2-methyl butanoic acid and verbenone with lowest water activity. The optimized formula of microencapsulation from the MAD extract and the OSA starch was 15%w/w of dry solid and 963.20 g per 1000 ml of water. The amount of main aromas that encapsulated in microcapsules wassignificant difference. Linalool content was the highest, followed by 2-methyl butanoic acid and verbenone. The release rate constant of three main compounds in simulated saliva followed Avrami’s equation calculation suggested that linalool had the slowest release rate constant (1.26 min^{-1}), followed by verbenone (0.53 min^{-1}) and 2-methyl butanoic acid (0.24 min^{-1}). This showed that linalool and verbenone were retained longer in the encapsulated matrix than 2-methyl butanoic acid resulting from higher molecular weight and those volatile compounds created encapsulated complex better than 2-methyl butanoic acid.

Fifthly, the optimization of the multi-core encapsulated flavor powder in GGA infused with the pandan flavor by response surface methodology was investigated. The optimized formula of multi-core encapsulated powder in GGA system was gelatin 3.00% w/v gum arabic 3.73% w/v and pandan flavor 5.26% w/w of gelatin-gum arabic solid with MAD flavor powder as a core material at 2.5% w/w. This formula provided the highest of yield recovery, encapsulation efficiency, the pandan release content, linalool aroma release, 2-methyl butanoic acid and verbenone with the lowest water activity. The pandan flavor release was first in the process simulated with hot water. Thereafter, the MAD flavor was released in SSF. Linalool content was the highest, followed by 2-methyl butanoic acid and verbenone. The release rate constant of three main compounds in SSF suggested that linalool had the slowest release rate constant (1.23 min^{-1}), followed by verbenone (0.91 min^{-1}) and 2-methyl butanoic acid (0.51 min^{-1}). This finding showed that linalool and verbenone were retained longer in the encapsulated matrix than 2-methyl butanoic acid resulting from higher molecular weight and those volatile compounds created encapsulated complex better that 2-methyl butanoic acid. The results suggested that the multi-core encapsulated flavor powder can retain the pandan flavor and release through high temperature and moisture production. In addition, the MAD flavor powder inside microcapsules was retained within product and can release through SSF.

Finally, the multi-core encapsulated flavor powder was applied in food model in NDMdessert. This part of experiment was investigatedthe suitable amount of flavor powder and the release model was investigated using Time intensity method (TI). The results revealed that the NDM dessert contained 1% w/w of the multi-core encapsulated flavor powder showed the most preferable of sensory preference. The consumer acceptance provided sensory rating score in range of 6.0–6.3. The product acceptance and purchase intention also evaluated with high percentage at 98.0% and 98.3%, respectively. The characteristics of dessert with 1% w/w of the multi-core encapsulated flavor powder were analyzed as color value (*L*,a** and *b**), hardness, adhesiveness, cohesiveness, springiness, gumminess, chewiness, pandan flavor content, 2-methylbutanoic acid content, linalool content, and verbenone content at the value of 44.64, 0.71, 9.74, 4522.24 g.Force, (-177.02) g.Force, 0.78, 0.74 cm, 3551.42 g.Force, 2639.69 g.Force, 122.40 µg/mL, 61.92 µg/mL, 84.73 µg/mL, and 42.15 µg/mL.The controlled release model in NDM dessert usingTI revealed that intensity of the pandan flavor and White Champaca flavor were 35.83 mm and 30.96 mm. Because of the pandan flavor was released prior to steaming processwhereasWhite Champaca flavor from MAD flavor powder was still contained within dessert matrix. The maximum intensity of pandan and white champaca flavor were 48.79 mm and 50.80 mm at 9th second. Moreover, the mechanic shear force from chewing was another factor that assists the flavor release in oral cavity. This showed a success on applying multi-core encapsulated flavor powder in NDM dessert to controlled release flavor of pandan and White Champaca.

8.2 Recommendation for further investigation

1. Variety type of scented plant should be studied further both quality and quantity to support scented flower industry in local area.

2. Controlled release model of multi-core encapsulated flavor powder should be studied in different release condition for more diversity of utilization

3. Other types of encapsulating carriers should be investigated in aspects of suitability of aroma encapsulating and releasing, and stability of aroma.

4. For more variation of usages, Multi-core encapsulated flavor powder should be investigated with different products and more diversity of utilization.

5. The MAD flavor powder and the multi-core encapsulated flavor powder should be investigated for stability during storage condition and its end of shelf-life prediction.