CHAPTER 6

CONCLUSIONS

6.1 In Thailand 32 species of stingless bees (Apidae: Meliponini) contained in 10 genera are described (Rasmussen, 2008). Not all stingless bee species are compatible for meliponiculture. The *Tetragonula laeviceps* and *T. pagdeni* species complexes are very opportunistic in nest cavity selection and adaptability to human-made hives. There is not a standard size for stingless bee hives. The structural of hives varies widely in volume. Wooden boxes, tree trunks and split logs which are then hollowed out by the beekeeper, are used, depending upon beekeeper preference.

6.2 Meliponiculture in Thailand could be characterized as in an emergent stage but expanding. During the past few decades stingless bees have been managed as expanding economic venture. The larger scale of stingless bee beekeeping is seen in the Southeast region of Thailand (Chanthaburi and Trat provinces). The first meliponiculture practices focused on using stingless bees for pollination of commercial fruit. Following the effective development of colony management techniques, honey and cerumen production were recognized as additional economic benefit for meliponiculturists.

6.3 Stingless bees store honey in pots, not in combs *as per* true honey bees (Oddo *et al*., 2008). The amount of honey from a stingless bee colony cannot compete with the honey bee. Honey produced by stingless bees is most often promoted as a natural medicinal remedy for a variety of ailments. This specific market niche makes the value of stingless bees honey often higher than *A. mellifera* honey (Vit *et al*., 1998). The medical of meliponine honey has been widely recognized (Cortopassi-Laurino *et al*., 2006; Souza *et al*., 2006; Vit *et al*., 2004). However, none of stingless bee honeys are included in published international standards. The International Honey Commission is considering establishing quality standards for stingless bee honey (Codex, 2001; Souza *et al*., 2006).

6.4 Nearly all research work concerning stingless bee honey physicochemical characteristics have been done in several countries of Central and South America. A recent summary of stingless bee honey physicochemical composition of *ca*. 32 species from Central and South America is found in Vit *et al*. (2013) (Appendix I). For Indo-Australian stingless bee honey physicochemical there is a scarcity of research. Previous research of stingless bee honey focused on species of stingless bee involved in 'commercial' meliponiculture.

6.5 Honey has a very complex composition its major compounds including monosaccharides; fructose and glucose, disaccharides, polysaccharides and minor components; amino acids, enzymes, vitamins and minerals. The composition of honey is dependent on its floral source and bee species. The quality of honey is mainly determined by its chemical, physical, sensory and microbiological characteristics (Iglesias *et al*., 2006). The changes of honey physicochemical are related to time and temperature storage (Castro-Vazquez *et al*., 2008; Gonzales *et al*., 1999; Sancho *et al*., 1992).

6.6 This research examined stingless bee honey from an expanded number of stingless bee species known in Thailand (11 of the described 32 species) and intra-specific variable in the species most commonly used in commercial stingless bee beekeeping (*T. laeviceps-pagdeni* complex). The physicochemical profile of 28 stingless bee honey samples, while displaying variability between species, conforms to previous finding for stingless bee honey from South America, but with some noted variations. When compared to the *A. mellifera* honey standards, Thai stingless bee honey revealed a higher moisture content (31 g/100g); higher ash content (0.531 g/100 g); higher electrical conductivity (1.1 ± 0.78 ms/cm); lower pH (3.6); higher acidity (164 meq/kg); lower diastase activity (1.5 °Gothe); slightly elevate HMF (8.7 mg/kg) and quantitatively lower total carbohydrates (total sugars, 51 g/100g).

Related to the sugar profiles, the disaccharide maltose was detected in only 3 of the 11 stingless bee species examined, but when present it was frequently the dominant carbohydrate. Maltose has been reported previously in stingless bee honey from South America (Bogdanov *et al*., 1996; Oddo, *et al*., 2008) but when present it is normally in small quantities. From our study maltose comprised 15 to 57 g/100g of the total carbohydrates in honeys were it was detected.

The investigation of multiple samples of *T. laeviceps-pagdeni* honey, where previous research on its honey composition has been performed (Suntiparapop *et al*., 2012) gave similar results to past research except for the parameters of a higher HMF and lower levels of the reducing sugars (fructose and glucose). A noticeable difference from our carbohydrate analysis of *T. laeviceps-pagdeni* honey is the near absence of sucrose (0.03 ± 0.02 g/100g) which is dissimilar to the report of Suntiparapop *et al*. (2012) who reporting higher sucrose levels (19.5 ± 0.1 g/100g and 18.9 ± 0.4 g/100g) of honey from the same stingless bee species and geographical region of Thailand where the majority of our *T. laeviceps-pagdeni* honey samples have been collected.

The physicochemical analyses of honey from nine species; *Tetrigona melanoleuca, Tetrigona apicalis, Homotrigona fimbriata, Lisotrigona furva, Tetragonula fuscobalteata, Tetragonula testaceitarsis, Tetragonilla collina, Lepidotrigona flavibasis* and *Lepidotrigona doipaensis* are the first reports for the honey from these species.

6.7 There is a near absence of studies which analyze the physicochemical change in stingless bee honey over the course of time and long term storage (Menezes *et al*., 2013). The physicochemical changes occurring in stingless bee honey over time and at three temperature storage regimes was studied. *T. laeviceps-pagdeni* honey was chosen as it presently dominates stingless bee honey production in Thailand.

The combined effects of time and storage temperature were statistically significant for pH, diastase and HMF. Our fresh honey HMF averaged 33.0 mg/kg and following time and temperature treatments, rose to a high of 5,667.5 ± 1627.3 mg/kg after 12 months of storage at 45°C. A statistical significance was demonstrated for the effect of time alone on total acidity. Our observed pH decrease over time was statistically significant. Our stingless bee honey also demonstrated significance in the rise in total acidity related to storage time which would be a primary cause for the observed decrease in pH. The parameters of moisture, ash, and EC demonstrated no statistical significance for either storage time or storage temperature. EC levels for *T. laeviceps-pagdeni* honey increased slightly over storage time.

Stingless bee honey carbohydrates were little affected by time and temperature, although the monosaccharide reducing sugars and the disaccharide maltose all experienced downward trends. Quantitatively maltose was the dominant sugar. Glucose and fructose were lower than previous reports of neo-tropical stingless bee honey and unchanged with time and temperature treatment.

Overall findings support the use of HMF as a valid indicator of storage and temperature effects, and confirm White's (1994) questioning the value of diastase as a suitable quality parameter. From the results stingless bee honey should be stored at low temperature (4°C) which honey maintains many of its properties during 12 months. However, for preserving the characteristics of fresh honey it is recommended to not extend the storage time.

6.8 This research provides the information on physicochemical together with the changes produced over time and temperature storage of stingless bee honey. It is beneficial for stingless bee beekeepers. These could be used as recommendation in the setting of national and international standards for stingless bee honey.