Chapter 2

Literature Review

Lime (*Citrus aurantifolia*) is a hybrid citrus fruit, which is typically round, green and contains acidic vesicles. It is one of the most popular citrus fruits and widely used as an ingredient to accent the flavors in a variety of Thai foods and beverages. It is an excellent source of health benefit bioactive compounds such as vitamin C, flavoniods, and phenolic contents etc.

2.1 Bioactive compounds of lime

Several species of citrus lime were investigated in vitamin C, total phenolic, and flavonoid contents which are sources of natural antioxidants (Ghafar, Prasad, Weng, & Ismail, 2010). Because of an excellent source of ascorbic acid and its antioxidant activity related to flavoniods, and phenolic contents, lime has many functional health benefits and nutritional properties such as preventing vitamin C deficiency diseases, heartburn and nausea, cooling fever, and easing coughs and reliefing variuos respiratory disorders (Theansuwan, Triratanasirichai, & Tangchaichit, 2008). Phenolic compounds from citrus lime are reported in the antioxidant capacity (Wang, Cao, & Prior, 1996). Flavonoids in lime have shown the potency in preventing some forms of cancer (Attaway, 1993). Citrus lime also contains significant quantities of aroma compounds such as camphene and limonene, which are the predominance composition in citrus oils highly found in lime juice (Tounsi et al., 2011). The total antioxidant capacity of these compounds depends on their stability during food processing and storage, including in digestive conditions. Therefore, it is of great interest to transform lime juice into dry powder with preserving their health potential properties and protect their qualities under undesirable conditions.

2.2 Lime powder production

Previous studies of the lime juice powder production using spray drying were proposed and the temperature used was 170°C with the addition of drying agents (maltodextrin, gum Arabic, sucrose syrup etc.), approximately 10-20% w/v to increase the mass product (Footrakul, Mawimol, & Boonyasupa, 2003). Roustapour et al. (2006) reported that the spray drying of lime juice was very difficult due to the low T_g. Recently, the production of lime juice powder by spray drying has been done with 10-30% drying agents (maltodextrin, gum Arabic, sucrose syrup etc.) based on its total soluble solids (TSS) content to increase the mass product and to overcome the stickiness problem (Shihawong, 2003). To overcome the stickiness problem, Footrakul et al. (2003) studied the effects of maltodextrin on the lime juice powder and evaluated its quality and sensory during storage. The results showed the stability of lime powder are extended at least 6 months to 1 year with 73% good acceptability reported in sensory analysis (Footrakul et al., 2003).

Zareifard, Niakousari, Shokrollahi, and Javadian (2012) studied drying system parameters of lime juice base on amount of drying agent (40-50%), spray drying conditions (temperature 140-170%), and powder recovery. The added encapsulating agent to facilitate drying also affects the quality of the final powder (Shihawong, 2003). Dib Taxi, De Menezes, Santos, and Grosso (2003) used carrier agents to protect vitamin C in camu-camu from heat and Mara Righetto and Maria Netto (2005) reported the increased stability of products in acerola powder on the effect of encapsulating materials agents. However, vitamin C, phenolic compound, citric acid, pH and acidity contained in fresh lime juice can be easily degraded by high temperature during drying process. For example, citric acid and ascorbic acid can be oxidized by air, light and hot temperature during thermal drying process. The study of Gil-Izquierdo, Gil, and Ferreres (2002) stated that vitamin C provided 70-90% of the total antioxidant capacity of orange juice after treated with 95°C for 30 s. The similar result found by Kuljarachanan, Devahastin, and Chiewchan (2009). The effect of 120°C thermal drying processes degraded the phenolic compounds, vitamin C, and limonin compound, which decreased the total antioxidant activity of the powdered lime. Owing to the drying air temperature that diminish heat sensitive compounds in citrus juice especially decreased total antioxidant capacity (Fazaeli et al., 2012) and the excessive use of maltodextrin cause a portion of the nutrient components change, a whitish appearance, and an off-flavor or medicine-like taste in the final powder, result in quality loss which is unaccepted in the spray drying process. Thus, drying operations must therefore be carefully developed to minimize the loss of the dried powder's properties.

2.3 Entrapment technique

The potential of entrapment to protect bioactive compounds during thermal-drying process was reported in several studies. Chuacharoen and Sabliov (2016) proved that the stability of bioactives was improved and their total antioxidant activities were enhanced when encapsulated in particles. The entrapment is to trap active compounds inside core particles surrounded by the protective shell, which is mostly food-grade, biodegradable materials such as maltodextrin, gum Arabic, and sodium caseinate. This process can protect the entrapped core against caking and stickiness, temperature and enzymatic changes. Gum Arabic has become an entrapment aid for essential oils due to its emulsifier properties. A combination of maltodextrin and gum arabic was reported for encapsulation of polyphenol compounds using spray drying technique. Fang and Bhandari (2012) compared the efficiency of maltodextrin and whey protein as drying agents on spray drying of sugary juice. They concluded that using low addition rate of protein minimized the stickiness problem by forming a thin film over the surface of the particles, which consequently reduce the surface adhesiveness among the particles compare to maltodextrin.

This project developed lime powder with entrapment process in use for spray-drying technology. The entrapment carrier was designed with a combination of maltodextrin and gum Arabic as a core to entrap bioactive compounds and cover on the surface of particles with the purpose of protecting its physicochemical properties. Spray-dried lime powder was analyzed for color, moisture, solubility, hygroscopicity, particle size, morphology, vitamin C, total phenolic content, total flavonoids, and antioxidant activity. The production of the powder using spray dryer was optimized to reach the highest quality of lime juice powder.