CHAPTER 1 INTRODUCTION

1.1 Research Rationale

The healthy food products that have natural ingredients or natural additives are of great interest to consumers. Natural antioxidants are one of the food additives used for extending the shelf life, improving nutritional value and functionality of foods. Phenolic compounds which are the natural antioxidants are widely used as food additive of many food products because of health benefits (Larson, 1988; Gerber et al., 2002; Kim et al., 2003; Kris-Etherton et al., 2002; Jang et al., 2007; Wojdylo et al., 2007; Tawaha et al., 2007). The rhizome of turmeric (*Curcuma longa* L.) is one of the herbs that are widely used as food ingredients, food additives and colouring agent in foods (Jayaprakasha et al., 2005; Surojanametakul et al., 2010; Sowbhagya et al., 2005). Curcuminoids are a major component of turmeric rhizomes. They have been found to be a rich source of phenolic compounds and possess high antioxidant activity (Selvam et al., 1995; Jayaprakasha et al., 2006; Ak and Gülçin, 2008). Many researchers have been done about the biological, physiological and chemical properties of the curcuminoids; they are anti-inflammatory, antimicrobial, antiparasitic, antitumor, antiviral and antimutagenic properties (Polasa et al., 1991; Selvam et al., 1995; Ruby et al., 1995; Ahsan et al., 1999; Masuda et al., 1999; Ramsewak et al., 2000; Jayaprakasha et al., 2006; Ak & Gülçin, 2008; Itokawa et al., 2008). Moreover, curcuminoids are also moderately stable to heat at the temperature below 100 $^\circ$C (Khatun et al., 2006; Temitope et al., 2010; Paramera et al., 2011). Thus, the application of turmeric rhizomes in foods is of interest.

Rice is one of the leading cereals worldwide and it is a staple food of over half of the world's population (Juliano, 1990). Rice can be consumed in different forms such as white rice, brown rice and processed rice such as parboiled rice. The consumption of rice depends on the region, culture and eating style of the consumers. Some consumers prefer to consume the white rice or milled rice since the cooked white rice provides the soft texture as compared to the cooked brown rice. However, the cooked brown rice is more superior to cooked white rice in terms of nutritional values and phytochemicals content. This is because the bran layers that are a rich source of minerals, vitamins and phytochemicals including antioxidants are removed from the rice grain during milling process to convert the brown rice as milled rice or white rice (Choi et al., 2007; Shen et al., 2009). Therefore, coating of white rice with natural antioxidants is one way to improve its functionality in term of the antioxidant capacity.

Coating of solid particles can be performed by many methods such as dipping, painting and spraying. However, spray coating is the popular method since it provides the uniformity and can control the thickness of coating layer. Spray coating can be performed in many types of equipment such as the rotating pan, rotating drum, fluid bed and other mixers. Of these, the spray coating in the rotating pan and fluid bed are most widely used for particle coating (Maronga, 1998). In the rotating pan, the particles are moved by rotating a pan and the coating solution is then sprayed onto the surface of agitated particles. During coating with rotating pan, the heated air is supplied to the rotating pan to dry the deposited solution on particle surface, leaving only the coating film. Although the rotating pan has been widely used for a long time; however, the rotating pan has low reproducibility and hence it is not suitable for coating particles that require high coating uniformity (Maronga, 1998). The fluidized bed coating technique has been developed and used in the pharmaceutical industries for a long time. Recently, the fluidized bed coating has been increasingly applied in the food industries (Dziezak, 1988; Dewettinck and Huyghebaert, 1999; Werner et al., 2007). There are three different configurations for fluidized bed coating but the top-spray has a greater possibility of success in the food industries when compared to bottom-spray and tangential-spray. This is because the top-spray fluidized bed coating is highly versatile and it can handle higher batch size and moreover, it is relatively simple to execute (Dewettinck and Huyghebaert, 1999). The operation with top-spray fluidized bed coating, the coating solution is sprayed onto the surface of fluidizing particles by a nozzle. The coating solution that adheres on the particle surface is dried due to the heated fluidizing air. The advantage of this coating technique is that the coating and drying takes place simultaneously in only one unit operation. Also, it can be used to coat the particles that have size in the range from 0.1 to several millimetres (Guignon et al., 2002).

However, in food industries, the top-spray fluidized bed coating is still a complicated coating process because of the greater volume. Also, this coating technique involves many sub-processing steps such as atomization, drying and fluidization. All of these sub-processes, the droplet formation, collision of droplet and particle, droplet spreading on particle surface and droplet evaporation occur almost simultaneously during coating process (Dewettinch and Huyghebaert, 1999). Thus, to obtain a high coating quality, fluidizing air temperature, fluidizing air velocity, spray rate of coating solution, atomization air pressure, inlet air relative humidity, particle properties and coating solution properties are the important parameters (Jones, 1985; Dewettinck and Huyghebaert, 1999; Werner et al., 2007). These parameters both directly and indirectly influence the coating qualities. The coating qualities are a measure of coating performance including coating efficiency, product quality and energy efficiency (Maa et al. 1996; Teunou and Poncelet, 2002).

As mentioned above, it is clear that product quality, coating efficiency and energy efficiency of TSFBC depend on many variables. The objectives of this work were therefore to study the effects of operating parameters including inlet air temperature and spray rate of coating solution on the quality of turmeric extract coated rice (TECR). Moreover, the effects of operating parameters including superficial air velocity, atomization air pressure and percentage of recycle exhaust air on the performance of TSFBC were also investigated.

1.2 Objectives

1.2.1 To produce the healthy coated rice namely TECR using the TSFBC.

1.2.2 To study the effects of operating parameters including inlet fluidizing air temperature and spray rate of coating solution on quality attributes of TECR.

1.2.3 To evaluate the performance of TSFBC at different superficial air velocities, atomization air pressures and percentages of recycled exhaust air.

1.3 Scopes

1.3.1 For each batch of coating, 5 kg of Jasmine white rice (Khao Dawk Mali-105) was used to provide the initial bed height of 10 cm.

1.3.2 The turmeric extract solution at a concentration of 4% (w/v) was used as the coating solution for all experimental conditions.

1.3.3 To study the effects of inlet fluidizing air temperature and spray rate of coating solution on quality attributes of turmeric extract coated rice (TECR), the experiments were carried out at spray rates of coating solution of 34, 40 and 46 mL/min, atomization air pressure of 1.5 bar (gauge pressure), spraying time of 12 min, superficial air velocity of 3 m/s, inlet fluidizing air temperatures of 50, 55 and 60 °C and the percentage of recycled exhaust air of 80%. The quality of TECR was evaluated in terms of final moisture content, percentage of fissured kernel, head coated rice yield, color, textural properties, total antioxidant capacity and total phenolics content.

1.3.4 To evaluate the performance of top-spray fluidized bed coater (TSFBC) for producing TECR at different superficial air velocities, atomization air pressures and percentages of recycled air, the experiments were performed at superficial air velocities of 2, 2.5 and 3 m/s and atomization air pressures of 1, 1.5 and 2 bar (gauge pressure) at percentage of recycled exhaust air of 80% and at without recycled exhaust air. The spray rates of coating solution, inlet fluidizing air temperatures and spraying time were fixed at 40 mL/min, 50 °C and 12 min, respectively. The performance of TSFBC was evaluated in terms of TECR quality, coating efficiency and energy efficiency. The quality of TECR was considered in terms of final moisture content, color, percentage of fissured kernels, head coated rice yield and the percentage of uncoated white rice kernels.

1.4 Expected Benefits

1.4.1 The information on the effects of operating parameters on the quality of coated rice and on the performance of top-spray fluidized bed coater for coating white rice kernels.

1.4.2 The information on the feasibility of top-spray fluidized coating technique for coating of white rice kernels.

1.4.3 The knowledge obtained from white rice kernels coating with top-spray fluidized bed technique that can be applied for other products.

1.5 Outline of Dissertation

This dissertation is built up of five chapters and one special topic. Following an introduction chapter, an overview about the theoretical backgrounds and the literature review that involve with this dissertation are presented in chapter 2. In chapter 3, it is the study that investigate the effects of inlet fluidizing air temperature and the spray rate of coating solution on the quality attributes of turmeric extract coated rice using top-spray fluidized bed coating technique. Next, chapter 4 is the study related partly to the performance evaluation of top-spray fluidized bed coating for producing the turmeric extract coated rice. Finally, chapter 5 is the part of conclusion and recommendations. In addition, the appendix presents the special topic that studies the quality and drying kinetics of instant parboiled rice fortified with turmeric using hot air and microwave-assisted hot air drying.