CHAPTER 1

Introduction

1.1 Statement and Significance of the Problems

Coffee pulp is a by-product during coffee bean production using wet process. In comparison to coffee silver skin and parchment, coffee pulp contributes to more than 60 percent of the overall quantity of coffee by-products (Murthy and Madhava Naidu, 2012). With increasing demand in coffee (Office of Agricultural Economics, 2013), the increasing amount of coffee pulps without proper management will eventually be a source of severe contamination and pose serious environmental problem. Thus, in order to develop sustainable industry, many utilization methods were proposed including microbial process (Orozco *et al.*, 2008), animal feed (Salinas-Rios *et al.*, 2015) and mushroom production (Calzada *et al.*, 1987). But, high amount of phenolic compounds in coffee pulps posed a challenge to those utilizations due to their toxicity and anti-nutritional property of the compounds (Pandey *et al.*, 2000).

Recently, Bioplastics have gained a significant interest over their petroleum-based counterparts because they can be fully degraded and produced from renewable sources. Thus, they are more eco-friendly to use. Bioplastics are plastics derived from biomass sources and can be made from agricultural by-products such as coffee pulp. Coffee pulp is mainly composed of lignocellulose material with addition of pectin and phenolic compounds (Murthy and Madhava Naidu, 2012). With the coffee pulp composition, bioplastic can be made based on cellulose and pectin as natural biopolymers. Pectin is one of the structural components of plant cell wall consisting of poly D-galacturonic acid attached with neutral sugars. Pectin is generally used as gelling, stabilizing and thickening agent. But with biodegradability, edibility, gelation, and physical and chemical stability, pectin is a suitable material for food coatings and packaging as well (Espitia *et al.*, 2014; Kang *et al.*, 2007). Cellulose is a linear, high molecular weight polymer and a biodegradable material. However, due to its strong hydrogen bonding,

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cellulose is hardly dissolved in common solvents. In order to utilize cellulose as plastic material, it must be converted into its derivatives. One of the most common derivatives is carboxymethyl cellulose (CMC). CMC is a water soluble, anionic polysaccharide used in various food application including food packaging (Ghanbarzadeh and Almasi, 2011; Ghanbarzadeh *et al.*, 2010; Rachtanapun *et al.*, 2012).

Coffee pulp is not only the source of natural polymers, but also a source of active compounds. The active compounds from coffee pulp are mainly polyphenols, which have chlorogenic acids as a major constitution (Esquivel and Jiménez, 2012). The benefit of chlorogenic acids include antioxidant (Xiang and Ning, 2008), antimicrobial (Lee and Sung, 2008; Lou *et al.*, 2011), anti-obesity (Cho *et al.*, 2010) and risk reduction of cardiovascular diseases (Bonita *et al.*, 2007). With the presence of both natural polymers and active compounds, coffee pulp is a suitable raw material for active food packaging that exhibits active properties of chlorogenic acids and structural integrity of pectin and CMC. But, the film based on either pectin or CMC alone has a film with low mechanical properties and highly sensitive to humidity (Guilbert and Gontard, 2005). Many polymer blends and composites were introduced to improve film properties of many bioplastics including polyelectrolytic film, which utilizes ionic interaction between polymers with opposite charges. The resulting blended structure would produce the film with better properties than those achieved from original polymer alone (Farris *et al.*, 2011). Consequently, to produce such a structure from coffee pulp, opposing charged polymers are required. Therefore, negatively charged pectin and CMC derived from coffee pulp were used with positively charged chitosan to produce polyelectrolyte bioplastic from coffee pulp.

Hence, the aims of this study are to produce a biodegradable plastic from coffee pulp based on pectin, CMC and chlorogenic acids by utilizing polyelectrolyte complex structure, characterize the resulting coffee pulp bioplastic and test for its capability as active food packaging.

1.2 Objectives

1.2.1 To study process and find optimum condition for pectin and chlorogenic acid extraction

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1.2.2 To study process and find optimum condition for CMC synthesis

1.2.3 To find optimum film formulation for coffee pulp bioplastic and characterize the film formulations

1.2.4 To evaluate coffee bioplastic for antioxidant activity, antimicrobial activity, biodegradability and effectiveness in extending shelf life of food product

1.3 Scope and Study

This thesis used coffee pulp of Arabica coffee (*Coffea arabica*) from wet process of coffee bean production as a raw material for a production of bioplastic. The pulps were obtained from Highland Research and Training Center (Chiang Mai University, Chiang Mai, Thailand) during December 2013. The plastic was made by casting a mixture containing crude coffee pulp extract (containing pectin and chlorogenic acids), CMC (synthesized from remaining solid residue after the extraction), glycerol (plasticizer) and chitosan (reinforcing agent to produce polyelectrolyte complex structure). The steps to partake the research were divided into 2 parts; production and characterization.

1.3.1 Production: This step involve study and optimization of 3 processes

1) Extraction of pectin and chlorogenic acids by acid-assisted aqueous extraction

2) CMC synthesis

3) Film formulation

1.3.2 Characterization: the final film formulation was characterized for its morphology, mechanical properties, water resistance, thermal property and functional groups. Then, it was tested for antioxidant activity, antimicrobial activity, biodegradability and ability to extend shelf life of food product using fresh cut carrot as a model.

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