CHAPTER 1

Introduction

1.1 Background and Rationale

Mango (*Mangifera indica* L.) is one of an economically important fruit of Thailand. Among all of the mango's cultivars, "Nam Dok Mai" mango is one of the most popular cultivar in the market due to its beautiful color, attractive fragrance, and delicious taste (Suwapanich, 2006). However, the amount of mango exported from Thailand to the world market is limited because it is very perishable and susceptible to postharvest decay. Among all of the postharvest diseases, anthracnose caused by *Colletotrichum* spp. is the most severe disease (Sangchote, 1987). The symptoms of infected mango fruits are expressed as dark, sunken lesions on ripe fruit with pink, slimy spore masses (Jeffries, Dodd, Jeger, & Plumbley, 1990). Furthermore, the excessive ethylene exposure during a fruit ripening can induce adverse physiological responses such as changes in color, respiration and softening (Wills, McGlasson, Graham, & Joyce, 1998; Tharanathan, Yashoda, & Prabha, 2006), leading to more susceptibility to postharvest diseases.

To prolong shelf life of mango fruits, low temperature storage, controlled/modified atmosphere storage or modified atmosphere can be used. However, these methods do not alleviate anthracnose and remove ethylene. Skin coating could be an alternative technique because it can provide the same effect as modified atmosphere storage and can also be used as a carrier for active agents to enhance its functionality (Dhall, 2013). However, the atmosphere created by skin coating has combined effects on fruit respiration, gas and water permeability. So, it can induce changes in flavor due to delayed ripening or as a result of anaerobic respiration which increases ethanol concentrations (Baldwin et al., 1999). Edible films or coating materials containing antimicrobial agents can be an alternative approach. The gradual release of an antimicrobial agent from edible films or active coating materials to the food surface may have advantages over dipping and spraying. In the latter processes, antimicrobial activity may be rapidly lost due to inactivation of the antimicrobials by food components or dilution below active concentration due to migration into the food matrix (Appendini & Hotchkiss, 2002). The active-coated papers which are coated with biopolymer mixed with natural antimicrobial substance may be an interesting alternative to avoid direct addition of preservatives into foods and respond with the demand for environmentally-friendly packaging materials.

Previous researchers had attempted to develop an active packaging paper by using various coating solutions (Kjellgren, Gällstedt, Engström, & Järnström, 2006; Rudra, Singh, Jyotia, & Shivhare, 2013). Among coating materials, chitosan and carboxymethyl cellulose (CMC) are attractive polymers for coating. The difference of the charge between chitosan and cellulose exhibits a good adhesion between a chitosan-based coating and a cellulosic material (Khwaldia, Arab-Tehrany, & Desobry, 2010). Moreover, free amino groups interfere with the negative charges of bacterial cell membranes, causing leakage of intracellular constituents (Liu, Du, Wang, & Sun, 2004). For CMC, it shows thermal gelatinization and forms films. It can be adsorbed to the fiber wall, increasing its surface charge density and improving the strength of paper formed (Laine, Lindström, Nordmark, & Risinger, 2002).

Vanillin is obtained from plant genus *Vanilla* which is a tropical climbing plant (Sinha, Sharma, & Sharma, 2008). It is generally regarded as a safe (GRAS) flavoring compound which is widely used in many industries, *i.e.*, foods, beverages, pharmaceutics and cosmetics (Medina et al., 2009). It is possible for application of vanillin in the anti-microbial packaging because vanillin has been shown extensively that it is an effective antimicrobial substance against yeast, mould and bacteria (Boonchird & Flegel, 1982; Lopez-Malo, Alzamora, & Argaiz, 1998; Fitzgerald et al., 2004). The antimicrobial properties of vanillin are involved with its aldehyde and hydroxyl groups. The aldehyde group of vanillin plays a key role in its antimicrobial activity while side-group position on the benzene ring also influences this activity (Fitzgerald, Stratford, Gasson, & Narbad, 2005). It is well known that aldehyde group is very reactive and can form covalent bonds with DNA and proteins, thereby potentially interfering with their normal functions (Feron et al., 1991; Fitzgerald et al., 2005). There are few studies of vanillin with regard to its antifungal effect in practical applications. Recent research regarding to the application of vanillin as antimicrobial substance incorporating with the wrapping film to control *Saccharomyces cerevisiae* and *Escherichia coli* in fresh-cut cantaloupe and pineapple have been reported by Sangsuwan, Rattanapanone, and Rachtanapun (2008). Likewise, Rakchoy, Suppakul, and Jinkarn (2009) have applied the vanillin solution for coating paperboard intended for packaging bakery product. A paperboard coated with vanillin could inhibit food-spoilage bacteria including *Escherichia coli*, *Bacillus cereus* and *Staphylococcus aureus*. It greatly extended the shelf-life of that bakery product. However, the application of vanillin as the antifungal substance incorporated into packaging for controlling microbiological quality of climacteric fruits during exportation is an interesting issue.

Likewise, the excessive ethylene exposure led to increased severity of anthracnose. Storage environment that can control ethylene produced by fruit itself may be more suitable to extend the storage life of mango fruit. One of the most effective materials to remove the ethylene is $KMnO_4$ (Wills et al., 1998). However, it is hazardous chemical and should be avoided. Some materials are safe, for instance, zeolite and activated carbon. Utilization of natural zeolite as an adsorbent has gained interest among researchers, mainly because its adsorption properties provide a combination of ion exchange and molecular sieve properties that can also be easily modified (Cincotti, Mameli, Locci, Orru, & Cao, 2006). The adsorption properties of activated carbon are unique, which include high surface area, high adsorption capacity, and various surface functional groups (Yang, 2003).

In the view of developing an active-coated paper, this study focus on vanillin as an antifungal agent, activated carbon and zeolite as ethylene adsorbents, and chitosan and carboxymethyl cellulose as bio-based coating materials. The objectives of this study were to investigate the efficacy of active-coated papers on the antifungal activity and ethylene removal, and to study disease incidence and quality attributes of mango fruits wrapped with active-coated papers. In addition, the release behavior of vanillin from active-coated papers were also determined.

1.2 Research Objectives

1.2.1 To develop an active-coated paper incorporating with vanillin and study its characterization.

1.2.2 To investigate the efficacy of active-coated paper incorporating with different concentrations of vanillin against mango anthracnose fungi.

1.2.3 To investigate the efficacy of active-coated paper incorporating with different ethylene adsorbents and its concentration on ethylene removal.

1.2.4 To study the disease incidence and the quality of mango fruits wrapped with active-coated paper during storage.

1.2.5 To study the release behavior of vanillin from active-coated paper and factors affecting its release behavior.

1.3 Research Usefulness

1.3.1 Get the active-coated paper with an effective antifungal effect for wrapping mango fruit.

1.3.2 Know the appropriate concentration of vanillin incorporated in active-coated paper and its antifungal effect against mango anthracnose fungi.

1.3.3 Know the type of ethylene adsorbent and its concentration that are effective to remove ethylene.

1.3.4 Understand the disease incidence and quality of mango fruits wrapped with active-coated paper during storage.

1.3.5 Understand the release behavior of vanillin in active-coated paper and factors affecting its release behavior.

1.3.6 The knowledge obtained become a useful information for the further research and is great for designing the effective active packaging system.

1.4 Scope of Research

The active-coated paper was formed from a standard bleached paper with 39 gsm using chitosan and carboxymethyl cellulose as coating material. Vanillin was used as an antifungal agent. Activated carbon and zeolite were used as an ethylene adsorbent. Their properties, antifungal activity and ethylene removal were studied. The disease incidence and quality attributes of mango fruits wrapped by active-coated papers were investigated. In addition, the release of vanillin from active-coated paper under different temperatures, relative humidity and pH as well as the release on mango fruits wrapped by active-coated paper were also determined.