CHAPTER ONE

GENERAL INTRODUCTION

Citrus (*Citrus sinesis* L.) is one of the major commercial fruit crops that is widely consumed both as fresh fruit or juice. Its global demand is attributed to its high vitamin C content and its antioxidant potential (Gorinstein *et al*., 2001). Citrus is mainly cultivated in the subtropical and tropical regions of the world between 40 ^{o} north and south latitude in over 137 countries on six continents (Ismail and Zhang, 2004). Brazil is the largest producer followed by the United States of America (USA), China and Mexico. Spain, USA and South Africa are the largest exporter countries followed by Turkey and Morocco (Citrus Commodity Notes, 2005). Citrus is an important fruit crop in international trade next to grapes requiring excellent quality and shelf life attributes.

Unfortunately, citrus is attacked by several plant pathogens that affect its fruit quality. In developing countries, where protection and proper handling of fresh fruit is inadequate, losses during transit and storage can represent in excess of 50% of the harvested crop (Eckert and Ogawa, 1985; Wisniewski and Wilson, 1992). Major postharvest losses have been recorded on the export markets associated with a range of pathogens. These include green and blue mould caused by *Penicillium* spp., gray mould caused by *Botrytis cinerea* Pers ex Fr (Agrios, 1997), Alternaria rot caused by *Alternaria citri* Elli and Pierce (Whiteside *et al*., 1988), anthracnose caused by *Colletotrichum gloeosporioides* Penz (Davies and Albrigo, 1994), Aspergillus rot caused by *Aspergillus niger* Van Tiegh, brown rot caused by *Phytophthora parasitica* Dast. (syn. *P. nicotianae* Breda de Haan), Diplodia stem-end rot caused by *Diplodia natalensis* Evans (Brown, 1994), sour rot caused by *Geotrichum candidum* Link ex Pers (Howard, 1936) and Trichoderma rot caused by *Trichoderma viride* Pos ex Gray (Whiteside *et al.*, 1988). However, it is often reported that the importance and impact of these pathogens on the citrus industry differ from country to country. Therefore, it is important for a country to first determine the spectrum and relevant importance of the pathogens involved in postharvest decay.

In Ethiopia, where agriculture constitutes more than 85% of the national income, citrus production is relatively small and was traditionally done for local consumption (Lipsky, 1962). Currently, citrus production in Ethiopia has expanded (FAO, 2004) with some private, association and government farms producing for local and export markets. Upper Awash

Agro-Industry is the largest Government owned enterprise that produces commercial tropical fruits and vegetables in the country. Although there are not much comprehensive data available for postharvest losses in Ethiopia, estimates by Eyob (1997) showed that more than 50% of the fresh fruit produced are lost postharvestly.

In order to reduce postharvest losses, synthetic fungicides are applied either pre- or postharvestly. However, the application of synthetic chemical compounds to control postharvest diseases often result in chemical residues on food that may affect human health (Norman, 1988) and development of resistant pathogens (Wilson and Wisniewski, 1989). Therefore, the development and use of alternative postharvest control options involving biological agents or natural plant extracts have become important since it is perceived as being environmentally safer and more acceptable to the general public (Janisiewicz and Korsten, 2002).

The citrus phylloplane harbour a large population of microorganisms adapted to survive and effectively compete in this environment (Janisiewicz and Korsten, 2000). Microorganisms identified as antagonistic fungal, yeast and bacterial species have been studied and evaluated for their potential in biocontrol programs (El-Ghaouth, *et al*., 2002; Janisiewicz and Korsten, 2002). Some antagonists have been commercialized for control of postharvest diseases of fruit such as those registered in South Africa for fruit disease control i.e. *Bacillus subtilis* (Avogreen) for the control of pre-and postharvest disease of avocado and *Cryptococcus albidus* (Yieldplus) for the control of postharvest diseases of apples and pears. Other commercial products such as *Pseudomonas syringae* (BioSave 110 and 111) to control *Geotrichum candidum* on pome fruit and citrus; *Candida oleophila* (Aspire ™) to control Penicillium decay on citrus and pome fruits have been registered by Ecogen Inc. in the USA (Shachnai *et al*., 1996). The search for new antagonists is however a continuous process and one can accept a significant growth in this market as new and more effective biocontrol agents are accepted onto the market.

However, biological control on its own is often less effective compared to commercial fungicides (Leverentz *et al*., 2003) or provides inconsistent levels of control. Therefore, to achieve a similar and consistent level of efficacy, the use of microbial antagonists integrated with commercial chemicals (Droby *et al*., 1998), hot water (Obagwu and Korsten, 2003), chloride salts (Wisniewski *et al*., 1995), carbonate salts (Obagwu and Korsten, 2003), natural plant extracts (Obagwu, 2003) and other physical treatments such as curing and heat treatments (Ikediala *et al*., 2002) have been used.

Plant extracts have long been used traditionally for control of plant diseases (Ark and Thompson, 1959). However, the actual use of these products in plant disease control is still lacking (Obagwu, 2003). Woody plants and shrubs, particularly of the tropical flora, provide a potential source of naturally produced inhibitory chemicals (Kubo and Nakanishi, 1979). Recently, volatile chemicals (Poswal, 1996; Obagwu, 2003; Dudareva *et al*., 2004; Singh *et al*., 2004), and essential oils (Plaza *et al.* 2004) from plant extracts were successful in controlling microbial diseases of some agricultural crops, stored fruits vegetables and food commodities. Mammed (2002) reported the strong anti-fungal activity of a non-identified plant species “muka ajua” of Ethiopia and has since been used for grain preservation in storage.

According to our knowledge, no survey on the identification of indigenous postharvest pathogens of high value crops such as cotton, coffee and citrus has been made in Ethiopia. Abate (1995) already reported this lack of information. The present study is therefore designed to identify the postharvest pathogens of sweet orange (*Citrus sinensis* L.) in Ethiopia, to determine the disease incidence caused by postharvest pathogens on citrus in storage and to screen and identify microbial antagonists and natural plant extracts for control of postharvest fruit decay. This study will also focus on the efficacy of the products under semi-commercial conditions and to determine the mode of action of the products in order to further register it for commercial use.

The objectives of this study were therefore to:

1. Determine the occurrence, distribution and disease incidence of major postharvest pathogens associated with decay of sweet orange.

2. Identify potential microbial antagonists from Ethiopian citrus and determine their efficacy under laboratory and packhouse conditions.

3. Select potential tropical plant extracts and determine their efficacy as disease control products under laboratory and packhouse conditions.

4. Evaluate microbial antagonists integrated treatment under *in vitro* condition as a control strategy option for postharvest citrus disease control.

5. Determine the mode of action of developed bio-pesticides.

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