CHAPTER 2
LITERATURE REVIEW

2.1 The *Allium* plants

The genus *Allium* has several economic important species such as garlic (*Allium sativum* L.), onion (*Allium cepa* L.), shallot (*Allium ascalonicum* L.), Japanese bunching onion (*Allium fistulosum* L.), leek (*Allium ampeloprasum* L.), wild chives (*Allium schoenoprasum* L.) and Chinese chives (*Allium tuberosum* Rottl. Ex Spreng) (Fig. 2.1). Plants in the family Alliaceae are native to central Asia. The best known feature of the alliums is their unique taste and smell. Shallot and onion contain simple sugars such as glucose, fructose and sucrose (Brewster, 1994). Nutritional information of shallot and onion is shown in Table 2.1.

Shallot and onion are generally consumed as uncooked and cooked, used in food manufacturing such as the condiment and seed production (Brewster, 1994). High quantity of shallot and onion is needed for domestic consumption and also exported to several countries (Office of Agricultural Economics, 2005). The quantity and value of their export is shown in Table 2.2. The value of export is more than million Baht and in the year 2006 the prediction of desire will increase.

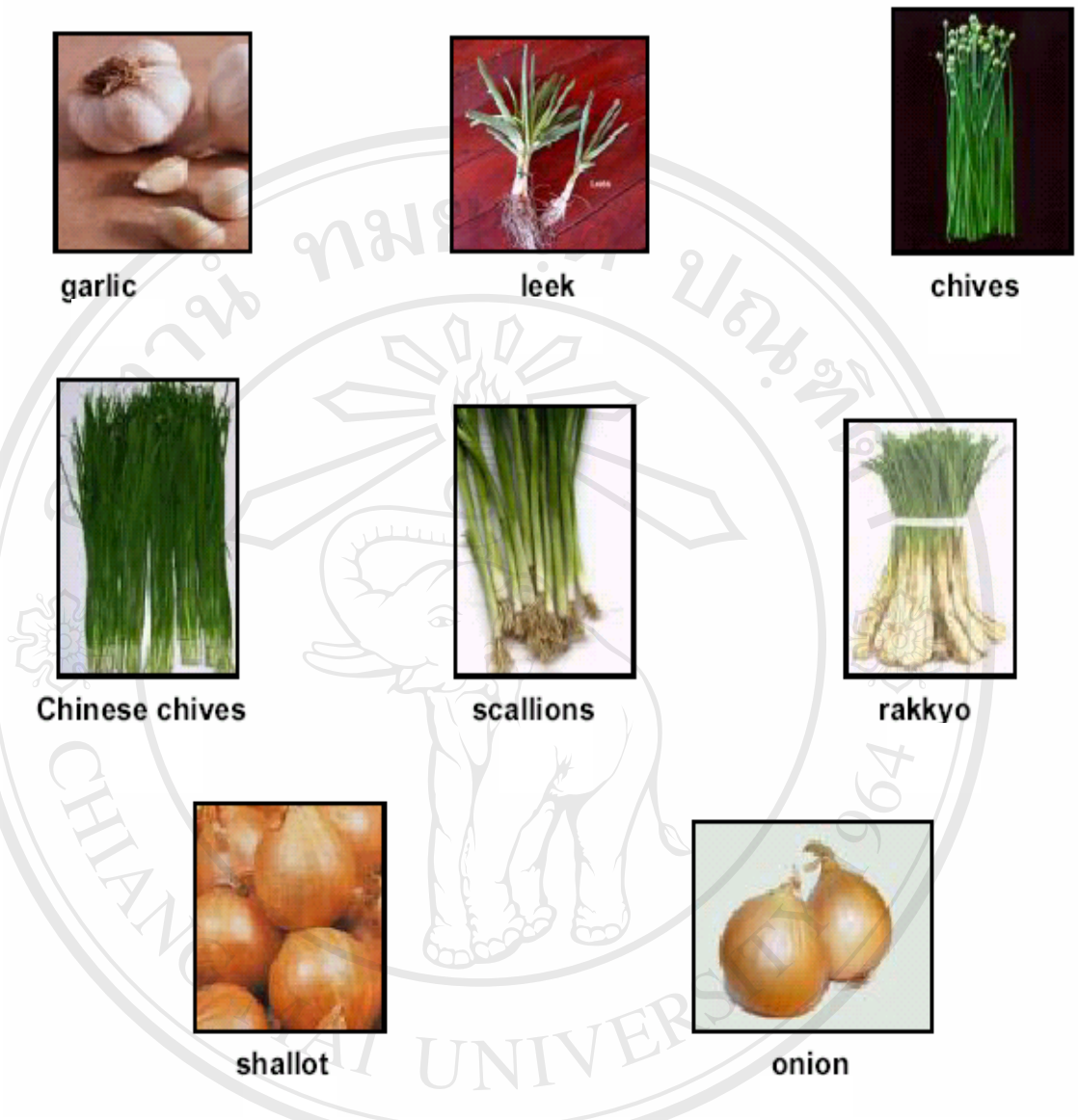

Fig. 2.1 Examples of *Allium* plants

Source: www.thaikitchen.com/ingredients.html

Table 2.1 Nutritional information for shallot and onion from 100 grams

	Shallot	**Onion**
Nutrition facts (%)	83.0	92.0
Water (%)	81.8	86.6
Energy (calories)	67.0	48.0
Protein (grams)	1.9	0.2
Fat (grams)	0.3	0.2
Carbohydrate (grams)	15.4	10.8
Fiber (grams)	0.7	0.7
Ash (grams)	0.6	0.6
Calcium (milligrams)	36.0	34.0
Phosphorus (milligrams)	45.0	63.0
Potassium (milligrams)	334.0	102.0
Zinc (milligrams)	0.6	0.7
Sodium (milligrams)	12.0	11.0
Vitamin A (IU)	5.0	-
Thiamine (milligrams)	0.03	0.03
Riboflavin (milligrams)	0.01	0.02
Niasin (milligrams)	0.10	0.40
Ascorbic acid (milligrams)	4.0	5.0

Source: Chaiyamongkon**,** No date

Table 2.2 Quantity and value of shallot and onion exports, 2001-2005

Quantity: ton

Value: million Baht

	2001		**2002**		**2003**		**2004**		**2005**	
	Quantity	Value	Quantity	Value	Quantity	value	Quantity	Value	Quantity	Value
shallot	61	3.63	172	2.05	45	1.58	108	2.05	194	3.57
onion	6,253	116.05	4,716	83.56	4,745	82.36	19,971	241.42	18,604	227.72

Source: Office of Agricultural Economics, 2006a; 2006b

2.2 The cultivation of shallot and onion

Most of shallot and onion are cultivated in the Northern Thailand such as Lamphun, Chiang Mai, Chiang Rai, Uttaradit, Phayao and Nakhon Sawan (Department of Agricultural Extension, 2006a; 2006b). The planted area and amount of shallot and onion production are shown in Table 2.3 and Table 2.4, respectively.

Table 2.3 Shallot: Area and production by whole kingdom

Plant area (Rai)			**Production (Tons)**		
2002	**2003**	**2004**	**2002**	**2003**	**2004**
102,783	105,925	112,896	193,899	173,336	232,537

Source: Department of Agricultural Extension, 2006a

Table 2.4 Onion: Area and production by whole kingdom

Plant area (Rai)			**Production (Tons)**		
2002	**2003**	**2004**	**2002**	**2003**	**2004**
17,448	15,143	17,672	69,292	37,881	88,500

Source: Department of Agricultural Extension, 2006b

2.3 Problems of crop production

The damage of shallot and onion occurs in several parts of cultivar according to many diseases as purple blotch, Stemphylium blight, anthracnose, downy mildew, Botrytis leaf blight, pink root, smut, smudge and several basal rots. Other damages are decay of bulbs, rotting, spoilage, weed and insect pest. These problems cause from temperature, moisture and unsuitable management (Shanmugasundaram, 2001).

2.4 Bulb crop storage

The bulbs of shallot and onion must be cured and dried throughly before being placed in the storage. They are normally placed in field containers and moved to a dry location for subsequent curing (Shanmugasundaram, 2001). After drying neck,

root and scale, they are stored at 25ºC for 5 months, and then transferred to 2ºC for long-term storage. The storage period of shallot and onion is 8-10 months and 6-7 months, respectively (Relf and McDaniel, 1999). Thai gardener store shallot and onion at room temperature which is the traditional method (Fig 2.2 (A)) but the storage period is shorter (Chaiyamongkon**,** No date).

(A) **(B)**

Fig. 2.2 Traditional method for drying of shallot **(A)** and product in the market **(B)**

2.5 Problems of bulb crop storage

During storage period, some problems are found such as sprouting (Brewster, 1994) and rotting of bulb (Kelly and Granberry, 2000). The main problems are cause from fungi. Fungal diseases including some of common field rot, botrytis neck rot causes by *Botrytis allii* and *Botrytis byssoidea*, bottom rot causes by *Fusarium oxysporum*, Basal rot causes by *Fusarium* species, and soft rot causes by various species of *Penicillium*. The important problem is black mold disease which causes by *A. niger* (Brewster, 1994). These problems result to the lost of storage yield of shallot and onion**.**

2.6 Management of of postharvest loss

The sprouting and rotting are controlled by using suitable temperature and dry moisture. Problem of black mold disease can be prevented by using some chemicals. At present, fungicides are used in order to control and prevent the problem such as

Manganeseethylenebis (dithiocarbamate) or Maneb (PBI Gondon Corporation, 2004), Zine ethylenebis (dithiocarbamate) or Zinneb (Amgrow Gardenking, 2004) and mancozeb or benzimidazole. However, some fungicides are hazardous substance and can contaminate in food products. Then, they may effect on human health and environment (University of Otago, 2003).

2.7 Synthetic chemicals in management of postharvest diseases

Fungicides are the primary means of controlling postharvest diseases. Their world-wide use is variable, comprising 26% of the plant protection market in Europe and Asia and 6% in the US. About 23 million kg of fungicides are applied to fruit and vegetables annually, and it is generally accepted that production and marketing of these perishable products would not be possible without their use (Regsdale and Sisler, 1994). However, as harvest fruit and vegetables are commonly treated with fungicides to retard postharvest diseases, there is a greater likelihood of direct human exposure to them than to chemicals that are applied solely to protect foliage. Further, the use of synthetic chemicals to control postharvest deterioration has been restricted due to their carcinogenicity, teratogenicity, high and acute residues toxicity, long degradation period, environmental pollution and their effects on food and other side-effects on humans (Lingk, 1991; Unnikrishnan and Nath, 2002). As well, phytotoxic and off-odour effects of some prevalent fungicides have limited their use. The disadvantage of these synthetic chemical is their potent side-effects, and also high cost (Tyler, 1992; Castro *et al*., 1999; Falandysz, 2000; Kast-Hutcheson *et al*., 2001; Sorour and Larink, 2001). In addition, synthetic fungicides can leave significant residues on treated commodities. Development of resistance to commonly used fungicides within populations of postharvest pathogens has also become a significant problem. The side-effects of synthetic fungicides means that alternative strategies need to be developed for reducing losses due to postharvest decay that are perceived as safe by the public and pose negligible risk to human health and environment (Wilson *et al*., 1999). The use of non-chemical methods and non-selective fungicide treatments may provide a part of this need. Inoculum reduction achieved through sanitation and exclusion, the use of non-selective fungicides (sodium carbonate,

sodium bicarbonate, active chlorine and sorbic acid) and physical treatments such as heat therapy, low temperature storage, hot water treatments and radiation can significantly lower the disease pressure on harvested commodities. Harvesting and handling techniques that minimize injury to the commodity, along with storage conditions that are optimum for maintaining host resistance will also aid in suppressing disease development after harvest. However, none of these treatments are consequently effective, and many cause damage to the commodities (Tripathi and Dubey, 2004).

2.8 Biocontrol agent from plants

Considerable attention has also been given to the potential of biological control of postharvest diseases of fruit and vegetables as a viable alternative to the use of synthetic fungicides. Microbial antagonists have been reported on a variety of harvested perishable commodities against a number of postharvest pathogens (Wisniewski *et al.*, 2001). Replacement of synthetic fungicides by natural substance, which are non-toxic and specific in their action, is gaining considerable attention. However, low efficacy and lack of consistency limit their use as a stand-alone treatment under commercial condition. These drawbacks in alternative methods have increased interest in developing further alternative control methods, particular those which are environmentally sound and biodegradable. The review deals with exploitation of natural products such as flavour compounds, acetic acid, jasmonates, some plants and plant extracts in the management of decay of fruit caused by plant pathogenic fungi were reported (Tripathi and Dubey, 2004).

The preservative feature of some plant extracts has been revealed for centuries and there has been renewed interest in the antimicrobial properties of extracts from aromatic plants. Some plants extracted in various organic solvents have shown inhibitory action against different storage fungi. However, active principle of some phytochemical have been isolated that showed strong inhibitory action against postharvest fungi (Tripathi and Dubey, 2004).

Plants may play an important role as a novel source of biological active compounds. Over past decade, there has been an elevated interst in searching for

antimicrobial agents from plant origin, as well as in isolating and identifying active compounds with possible to use in integrated crop protection and pest management programmes (Eksteen *et al*., 2001).

Plant provides a source of inspiration for novel drug compounds as plant derived medicines have made large contributions to human health and well being. Furthermore, there is an increment use of herbal products all over the world. The investigation of certain indigenous plants for their antimicrobial properties may yield useful results (El Astal *et al*., 2005).

The presence of antifungal compounds in higher plants has been recognized as an important factor in disease resistance. Plant extracts might have inhibitor inhibit enzymes from the invading pathogen, and the effects of different phenolic compounds on the germination and growth of many fungal pathogens were studied by Ismail *et al*. (1987). Such compounds, being biodegradable and selective in their toxicity, are considered valuable for controlling some plant diseases.

Most of Thai traditional plants have the antioxidant and antimicrobial compounds such as phenolic compounds which inhibit the microorganisms (Karuwanna *et al*., 2003; Vudhivanich, 2003; Phongpaichit *et al.*, 2005). The antimicrobial activity depends on type of plant, composition and concentration of plant active ingredient, extraction method and storage. However, their activity relies on invaded microbial species and occurrence level (Souza *et al*., 2005).

2.8.1 Garlic

The herb has brought the use of medicinal plants to the forefront of pharmacological investigation, and many new drugs are being discovered (Harris *et al*., 2001). Garlic (*Allium sativum* L.) or Krathiam has a wide spectrum of actions. It has been utilized as drug for thousands of year due to its medicinal property. The investigation into its mode of action is an interesting issue because it not only has antibacterial, antiviral, antifungal and antiprotozoal activity, but also beneficial effects on the cardiovascular and immune systems (Tattelman, 2005). Bianchi *et al*. (1997) studied the effects of garlic on the development of mycelium in the following phytopathogenic fungi: *Fusarium. solani, Rhizoctonic solani, Pythium ultimum* and

Colletotrichum lindemuthianum. In the *in vitro* test, it was found that the garlic powder used in water suspension demonstrated a good antifungal activity against the pathogenic fungi tested. Mycelial development of the fungi was strongly inhibited at the maximum concentration of the water extract tested. The water garlic extract could inhibit *Staphylococcus enteritidis*, *Staphylococcus aureus* (Benkeblia, 2004), *Escherichia coli*, *Campylobacter jejuni* and *Listeria monocytogenes* (Smith-Palmer *et al*., 1998), *Phytophthora infestans* (Ke-Qiang and Bruggen, 2001), *A. niger*, *Penicillum cyclopium* and *F. oxysporum* (Benkelia, 2004). Moreover, the ethanolic garlic extract could inhibit *S. aureus*, *Bacillus* spp., *E. coli* and *Salmonella* spp. (Onyeagba *et al*., 2004). A concentrated garlic extract containing 34% allicin, 44% total thiosulfinates, and 20% vinyldithiins possessed potent *in vitro* fungistatic and fungicidal activity against three different isolates of *Cryptococcus neoformans*. The minimum inhibitory concentration of the concentrated garlic extract against 1×10^5 organisms of *C. neoformans* ranged from 6 to 12 μg/mL. Furthermore, *in vitro* synergistic fungistatic activity with amphotericin B was demonstrated against all isolates of *C. neoformans*. Pure allicin was found to have a high anticandidal activity with a minimum inhibitory concentration of 7 μg/mL. Allicin was assumed to be the main component responsible for the inhibition of fungal growth. It inhibits both germination of spores and growth of hyphae. The various clinically important yeasts are significantly sensitive to a pure preparation of allicin. The mode of action of allicin on the fungal cell has not been elucidated but it is assumed to function on thiol enzymes as in other microorganisms (Ankri and Mirelman, 1999). Moreover, garlic extract also have a strong antifungal effect and inhibit the formation of mycotoxin like aflatoxin of *Aspergillus parasiticus* (Lawson, 1996).

2.8.2 Galangal

Galangal (*Alpinia nigra* B.L.) or Kha is an aromatic agent, carminative, stomachic, antispasmodic, antiphlogistic, antibacterial agent (Ravindran and Balachandran, 2004). It is used to relieve nausea, flatulence, dyspepsia, rheumatism, catarrh and enteritis (Hopking, 2006). It also possesses tonic qualities and used in veterinary and homeopathic medicine (*Alpinia officinarum*, 2004). Galangal has been

used both in Europe and Asia as an aphrodissiac. In Asia, galangal is used to treat catarrh and respiratory problems (Jirovetz *et al*., 2003). In China, galangal is a warming herb used to ease abdominal pain, vomiting and hiccup, as well as for diarrhea due to internal cold (Isabell, 2005). In India and Southwest Asia, galangal is considered to stomachic, anti-inflammatory, expectorant and a nervine tonic agent (Haraguchi *et al*., 1996). It is used in the treatment of hiccup, dyspepsia, stomach pain, rheumatoid arthritis and intermittent fever. It is also used as a body deodorizer and halitosis remedy (Belt, 2006). Galangal infusion can be used to alleviate painful canker sores and sore gums. Galangal has long been recommended as a treatment for seasickness. It can be used with other antifungal herbs as a part of a regimen to treat intestinal candidiasis (Herb facts, 1995).

Many reports presented the antimicrobial property from the galangal extract. Ficker *et al*. (2003) tested the extracts of eleven plant speices belonging to the Zingiberacaea for the antifungal activity by using disc diffusion bioassays. *Alpinia galanga, Alpinia mutica, Curcuma zedoaria, Costus globosus, Etlingera elatior, Etlingera littoralis, Hedychium cylindricum, Hornstedtia* sp., *Zingiber pachysiphon* and *Zingiber purpureum* were extracted with the ethanol for testing antifungal activity against *Candida albicans, C. neoformans, Saccharomyces cerevisiae, Wangiella dermatitidis, Alternaria alternata, Aspergillus fumigatus, F. oxysporum, Microsporum gypseum, Pseudomonas boydii, Rhizopus* sp. and *Trichophyton mentagrophytes*. It was found that seven of the tested members of Zingiberacaea contain potent inhibitors of the fungal growth. The extracts from rhizomes of *A. galanga, C. zedoaria* and *Z. purpureum* had pronounced inhibitory activities against a wide range of fungi. Rhizome extracts from these species and *Z. officinale* were notable as inhibitors of *Rhizopus* sp.. It can be concluded that the extracts from members of the Zingiberacaea could inhibit the fungal growth. Among different parts including the rhizome, fruit, inflorescence and stalk, the rhizome had highest activity.

2.8.3 Ginger

Ginger (*Zingiber officinale*) or Khing is indigenous to Southeast Asia and has traditionally been used internally for motion sickness, indigestion, colic, abdominal

chill, cold, cough, flue and peripheral circulatory problem (Singh *et al*., 2003). Ginger is an effective antioxidant and antimicrobial. Essential oil from rhizomes of *Z. officinale* was found to decrease growth rate of a variety of bacteria and fungi (Tan and Vanitha, 2004). The hot water extract of ginger could inhibit *F. oxysporum*, *A. niger* and *Aspergillus flavus* (Okigbo and Nmeka, 2005). The essential oil from ginger had antimicrobial activity against *A. fumigatus* (Jantan *et al*., 2003).

2.8.4 Lemon grass

Lemon grass (*Cymbopogon citratus*) or Takrai is widely used as food ingredient in Thailand and also in medicinal purposes. The lemon grass is rich in a substance called citral, the active ingredient in lemon peel. Lemon grass can use to relieve fever, stomach cramp, muscle cramp, flatulence, colic, arthritic pain, rheumatism, headache and general digestive aid (Meyer, 2006). Lemon grass oil has a broad range of antibacterial and anti fungal property (Felton Grimwade & Bickford Pty Ltd, 2004). Thus, lemon grass is generally recognized as safe for human consumption as a plant extract (Lemon grass, 1997).

Nwachukwu and Umechuruba (2001) investigated the effects of lemon grass (*C. citratus*) leaf extracts on major seed borne fungi i.e. *A. niger, A. flavus, F. moniliforme* and *Botryodiplodia theobromae* of African yam beam seeds. They were tested *in vitro* and *in vivo*. The results showed that it could inhibit the growth of all fungi tested. However, the inhibition of the growth of fungi varied with concentration, as well as the type of fungi.

2.8.5 Shallot

Shallot (*Allium ascalonicum* L.) or Hom-daeng is annual herbaceous plant cultivated widely from Central to Southwest Asia. Underground bulb comprises garlic-like cloves. Shallot bulb contains a volatile oil, and used as flavouring or seasoning agent. Therapeutic properties of shallot are the alleviation of stomach discomfort, anti-helmintic, anti-diarrhoeal, expectorant, anti-tussive, diuretic and anti-flu agent (Thai Herbs and Spices, 2003).

Yin and Tsao (1999) reported that three *Aspergillus* species, *A. niger, A. flavus* and *A. fumigatus* were inhibit by seven *Allium* plant extracts, garlic, bakeri garlic, Chinese leek, Chinese chive, scallion, onion bulb and shallot bulb. The results showed that all *Allium* plant extracts could inhibit against the growth of the three test fungi at 25°C. For the influence of heat, acetic acid or salt upon the antifungal activity of *Allium* plants, it was found that garlic bulb showed the greatest antifungal activity against these fungi in all treatments, followed by Chinese leek or Chinese chive. The combination of acetic acid and heat treatment gave similar inhibitory effect to heat treatments but the activity was decreased when the temperature of treatment increased. On the other hand, the influence of heat plus salt and acetic acid plus salt were similar to heat treatment alone or acetic acid treatment alone.

2.8.6 Onion

Onion (*Allium fistulosum* L.) or Hom-yai is known for its nutritional value and for the utility as herbal medicine in several countries. Onion is edible with a distinctive strong flavour and pungent odor which is mellowed and sweetened by cooking (Randle, 1997). For the therapeutic use, onion and its stalk have power to prevent and treat certain illness. Onion is a stimulant and mild counter irritant. Crushed raw onion can be applied on the forehead to get relief from headache. It helps in coronary heart disease, thrombosis and blood pressure. This use of onion is controversial. However, Ismail (2004) reported on conflicted result of this property.

2.8.7 Other plants

As the environmental and human health concerning. The extensive studies have been investigated the antimicrobial activity of various plant. Most work was done in the *in vitro* more than *in vivo* test. Some research aim to get active compound against food spoilage fungi (Thyahavoja and Hosono, 1996; Hsieh *et al.*, 2001) and human pathogenic microorganism (Janovhion *et al.*, 2003; Somchit, *et al.*, 2003). Many works had deal with problem in plant such as tomato rot-fungi (Ejechi *et al.*, 1999), plant pathogenic fungi (Bajwa *et al.*, 2003; Okemo *et al.*, 2003) and plant

pathogenic bacteria (Vudhivanich, 2003). Moreover, some plant extract has other properties such as inhibition the production of aflatoxin (Mahmoud, 1999) and inhibition of spore and conidial germination (Alam *et al.*, 2002). From many reports, each plant shows different properties against various microorganisms. In addition, the type of solvent used for extraction also affects the inhibition ability (Grierson and Afolayan, 1999; Mahasneh and El-oqlah, 1999). The previous reports on the inhibitory effect of plant extract on microorganisms are concluded in Tables 2.5 to 2.14.

Table 2.5 Antimicrobial ability of extracted plant by the distilled water

Plants	Microorganisms	References
Inula viscose *Savia fruticosa* *Ammi visnaya*	*Bacillus subtilis, Sarcina lutea, S. aureus,* *Trichophyton rubrum, Microsporum canis*	Maoz and Neeman (1998)
Grewia occidentalis	*S. aureus, Enterobacter cloacae*	Grierson and Afolayan (1999)
Polystichum pungens *Cyclamen persicum* *Ononis spinosa* *Bryonia syriasa*	*E. cloacae* *S. aurues, B. subtilis, E. coli, Salmonella typhimurium, C. albicans, A. flavus, F. moniliforme*	Mahasneh and El-oqlah (1999)
Lupinus albus *Ammi visnaga* *Xanthium pungens*	*A. flavus*	Mahmoud (1999)
Chelidonium majus L.	*Fusarium* strains	Matos *et al*. (1999)
S. capensis	*Mucor hiemalis, A. alternaria*	Masika and Afolayan (2002)
Vitex negundo	*Stemphium wallr, Hyloflora ramose*	Zafar *et al*. (2002)
Parthenium hysterophorus	*Drechslera tetramera, A. niger, Phoma glomerata*	Bajwa *et al*. (2003)
Cassia alata	*C. albicans, S. aureus*	Somchit *et al*. (2003)
Syzygium jambolanum	*A. flavus, A. fumigatus, A. niger, B. subtilis, S. aureus*	Chandrasekaran and Venkatesalu (2004)

Table 2.5 (continued)

Plants	Microorganisms	References
Salvia officinalis	*E. coli, Proteus mirabilis, E. cloacae, C. albicans, Klebsiella pneumoniae, Pseudomonas aeruginosa, Acinetobacter haemolyticus, Enterococcus* sp., *Salmonella typhi, S. aureus,*	El Astal *et al*. (2005)
Thymus vulgaris	*E. coli, K. pneumoniae, E. cloacae, A. haemolyticus, S. aureus*	
Petroselinum sativum	*P. aeruginosa*	
Sapindus emarginatus	*Pseudomonas testoosteroni, K. pneumoniae, B. subtilis, Micrococcus flavus, Proteus morganii, Staphylococcus epidermidis*	Nair *et al*. (2005)
Nyctanthes arbortristis	*P. testoosteroni*	
Dictyota spp.	*S. epidermidis, B. subtilis*	

Table 2.6 Antimicrobial ability of extracted plant by ethanol

Plants	Microorganisms	References
Alangium indica *Tachyspermum ammi* *Terminalia Bellerica* *Acacia catechu* *Plumbago indica*	*B. subtilis, S. aureus, E. coli, P. aeruginosa, C. albicans, A. niger*	Valsaraj *et a*l. (1997)
Melia azedarach	*A. flavus, F. moniliforme, M. canis, C. albicans*	Carpinella *et al*. (1999)
C. persicum *O. spinosa* *B. syriasa*	*S. aurues, B. subtilis, E. coli, S. typhimurium, C. albicans, A. flavus, F. moniliforme*	Mahasneh and El-oqlah (1999)
C. majus L.	*Fusarium* strains	Matos *et al*. (1999)
Zuccagnia punctata *Larrea divaricata* *L. cuneifolia* *Prosopanche Americana*	Eight filamentous fungi *Saccharomyces carlsbergensis, Rhodotorula* spp.	Quiroga *et al*. (2001)
Datura anoxia *Broussontia papyrifera*	*A. niger, S. wallr* *Fusarium chlamdosporum, S. wallr, H. ramose*	Zafar *et al*. (2002)
Pimpinella anisum	*Micrococcus leteus, Mycobacterium smegmatus*	Ates and Erdogrul (2003)

Table 2.6 (continued)

Plants	Microorganisms	References
Glycyrrhiza glabra *C. cassia*	*B. cereus, B. megaterium, B. subtilis, K. pneumoniae, M. leteus, S. aureus, M. smegmatus* *B. Megaterium, Entercoccus faecalis*	Ates and Erdogrul (2003)
Sanguisorba officinalis *Tussilago farfara* *C. majus* *Tribulus terrestris* *Schisandra chinensis*	*B. subtilis, E. coli, S. aureus, P. aeruginosa, C. albicans*	Janovska *et al*. (2003)
C. alata	*C. albicans, S. aureus*	Somchit *et al*. (2003)
Rhus coriaria L.	*B. cereus, B. megaterium, B. subtilis, S. enteritidis Bacillus thuringiensis, L. monocytogenes, S. aureus, Citrobacter freundii, Proteus vulgaris, Hafnia alvei, E. coli* type I, *E. coli* O157:H7,	Nasar-Abbas *et al*. (2004)
Rhinacanthus nasutus L.	*P. vulgaris, C. albicans*	Sattar *et al*. (2004)
S. officinalis *T. vulgaris*	*P. aeruginosa, S. aureus* *K. pneumoniae, S. aureus, Enterococcus* sp.	El Astal *et al*. (2005)

Table 2.7 Antimicrobial ability of extracted plant by methanol

Plants	Microorganisms	References
Cheilanthen viridis	*B. cereus, B. pumilus, B. subtilis, M. kristinae, S. aureus, P. aeruginosa, Enterobacter cloacae*	Grierson and Afolayan (1999)
C. majus L.	*Fusarium* strains	Matos *et al*. (1999)
Lythrum salicaria *Epilobium angustifolium* *Filipendula ulmaria* *Matricaris recutita* *Rubus chamaemorus* *Tanacetum* *Betula pubescens* *A. cepa*	*A. niger, C. albicans* *C. albicans* *E. coli* *S. aureus*	Rauha *et al*. (2000)
Acer nikoense *Glycyrrhiza glabra* *Thea sinensis*	*Arthrinium sacchari* M001	Sato *et al*. (2000)
Glycyrhiza glabra *Eucomis autumnalis* *Schrebera alata*	*Chaetomium funicola* *B. cinerea, Botryosphaeria dothidea, R. solani* *Verticillium dahliae*	Eksteen *et al*. (2001)

Table 2.7 (continued)

Plants	Microorganisms	References
Lapholaena sp.	*Pythium autumnalis*	Eksten *et al*. (2001)
Combretim caffrum	*A. alternaria, Schizophyllum commune, A. niger, Penicillium notatum*	Masika and Afolayan (2002)
Aglaia odorata Lour.	*Colletotrichum gloeosporioides*	Thongsri and Phuwiwit (2002)
Maesa lanceolata	*P. crytogea, Trichoderma uirens, R. solani, Phoma* sp., *F. oxysporium, Pythium ultimum, Pyrenophora teres Sclerotium rolfsii, Cochliobolus heterostrophus, A. niger*	Okemo *et al*. (2003)
Eucalyptus camaldulensis *Terminalia catappa* *Dianthus caryophyllus* L.	*B. subtilis, S. aureus*	Babayi *et al*. (2004)
T. chebula (Gaertner) Retz. *M. communis* L.	*P. aeruginosa, Pseudomonas fluorescens*	Bonjar and Nik (2004)
C. alata *C. fistula* *C. tora*	*Trichophyton rubrum, Microsporum gypseum* *Penicillium marneffei, M. gypseum* *M. gypseum*	Phongpaichit *et al*. (2004)
S. officinalis *T. vulgaris*	*P. aeruginosa, S. aureus*	El Astal *et al*. (2005)

Table 2.7 (continued)

Plants	Microorganisms	References
P. sativum	*P. aeruginosa, S. aureus*	El Astal *et al*. (2005)
Colocasia esculenta	*K. pneumoniae*	Nair *et al*. (2005)

Table 2.8 Antimicrobial ability of extracted plant by acetone

Plants	Microorganisms	References
Polystichum pungens	*E. cloacae*	Grierson and Afolayan (1999)
C. majus L.	*Fusarium* strains	Matos *et al*. (1999)
S. capensis *Schotia latifolia*	*A. alternaria, M. hiemalis,* P. notatum, *S. commune* *M. hiemalis, A. alternaria, S. commune*	Masika and Afolayan (2002)

Table 2.9 Antimicrobial ability of extracted plant by phenol

Plants	Microorganisms	References
Dennetia tripetala	*S. cerevisiae*, *Saccharomyces* sp., *Candida tropicalis*, *Cryptococcus* sp., *Geotrichum* sp., *Rhizopus stolonifer*, *A. niger*, *Fusarium* sp.	Ejechi *et al*. (1999)
S. officinalis *T. vulgaris*	*S. aureus*, *Enterococcus* sp.	El Astal *et al*. (2005)

Table 2.10 Antimicrobial ability of extracted plant by petroleum ether

Plants	Microorganisms	References
Stellaria media *Salvia syriaca* *Cardaria draba* *Euphorbia prostrate* *Rubia tinctoria* *Arbutus andrachnel* *C. persicum* *O. spinosa* *B. syriasa*	*S. aurues, B. subtilis, E. coli,* *S. typhimurium, C. albicans, A. flavus,* *F. moniliforme*	Mahasneh and El-oqlah (1999)

Table 2.11 Antimicrobial ability of extracted plant by dichloromethane

Plants	Microorganisms	References
Alpinia rafflesiana *Alpinia mutica* *Alpinia nutans* *Zingiber macroglossum*	*B. subtilis, P. aeruginosa, Aspergillus ochraceous* *B. subtilis, P. aeruginosa*	Habsah *et al*. (2000)

Table 2.12 Antimicrobial ability of extracted plant by chloroform

Plants	Microorganisms	References
V. negundo	*H. ramose*, *R. niger*	Zafar et al. (2002)
M. lanceolata	*Phytophthora crytogea*, *Trichoderma uirens*, *A. niger*, *Phoma* sp., *F. oxysporium*, *P. ultimum*, *R. solani*, *S. rolfsii*, *C. heterostrophus*, *P. teres*	Okemo *et al*. (2003)
Garcinia indica	*A. flavus*	Selvi *et al*. (2003)

Table 2.13 Antimicrobial ability of extracted plant by hexane

Plants	Microorganisms	References
V. negundo *Melia azedarach* L. *D. anoxia* *B. papyrifera*	*A. niger*, *R. niger* *H. ramose*, *A. niger* *A. niger*, *S. wallr* *F. chlamdosporum*, *S. wallr*, *H. ramose*	Zafar *et al*. (2002)
M. lanceolata	*P. crytogea*, *T. uirens*, *A. niger*, *Phoma* sp., *P. teres*, *F. oxysporium*, *P. ultimum*, *R. solani*, *S. rolfsii*, *C. heterostrophus*,	Okemo *et al*. (2003)
Parinarium glaberrimum Hassk	*B. subtilis*, *B. cereus*, *S. aureus*, *M. luteus*, *E. coli*, *C. albicans*, *S. enteritidis*, *Pichia anomala*, *S. cerevisiae*, *R. stolonifer*, *Zigosaccharomyces* sp., *F. oxysporum*, *G. candidum*	Moniharapon and Hashinaga (2004)

Table 2.14 Antimicrobial ability of extracted plant by ethyl acetate

Plants	Microorganisms	References
G. glabra	*Bacillus brevis* FM3, *B. cereus* EU, *M. leteus* LA2971, *B. megaterium* DSM 32, *P. aeruginosa*, *Enterococcus faecalis*, *K. monocytogenes* SCOTT, *Mycobacterium smegmatus* RUT	Ates and Erdogrul (2003)
Drosera montana *Drosera brevifolia*	*S. aureus*, *E. faecium*, *P. aeruginosa*, *E. coli*, *S. choleraesuis*, *K. pneumoniae*, *C. albicans*	Ferreira *et al*. (2004)
P. glaberrimum Hassk	*B. subtilis*, *B. cereus*, *S. aureus*, *M. luteus*, *E. coli*, *S. enteritidis*, *C. albicans*, *P. anomala*, *S. cerevisiae*, *Zigosaccharomyces* sp., *R. stolonifer*, *C. acutatum*, *Geotrichum candidum*, *Penicillium expansum*, *Penicillium italicum*, *B. cinerea*, *Phytophora citrophora*, *Monilinia fructicola*, *F. oxysporum*	Moniharapon and Hashinaga (2004)

2.9 Concluding remarks

It can be concluded that many plants show the biological properties against microorganisms. Thus, natural Thai plant extracts may provide an alternative way to prevent and control the fungal disease of *Allium* plants.