CHAPTER 2

LITERATURE REVIEW

2.1 Housefly, (*Musca domestica*)

2.1.1 Brief Explanation

Housefly, *Musca domestica*, a common insect of the family Muscidae, which means two-winged flies especially the housefly (the free dictionary, 2015), within the order Diptera which are a large order of insects having a single pair of wings and sucking or piercing mouths; includes true flies and mosquitoes and gnats and crane flies (the free dictionary, 2015). About 90 percent of all flies occurring in human habitations are houseflies. Once a major nuisance and hazard to public health in cities, houseflies are still a problem wherever decomposing organic waste and garbage are allowed to accumulate (Abdullah and *et al*, 2014).

2.1.2 Flies General Taxonomy

Flies are classified under the order Diptera within Class Insecta. Flies were further classified under the family of Muscidae under the subfamily of Muscinae (McLeod *et al*, 2012).

2.1.3 Taxonomy of Flies (*Musca domestica*)

The taxonomic hierarchy of *Musca domestica* is as follow:

Domain	:	Eukrya
Kingdom	:	Animalia
Phylum	:	Arthropoda
Subphylum	:	Hexapoda
Subphylum	:	Uniramia
Class	:	Insecta

Subclass	:	Pterygota
Suborder	:	Brachycera
Order	:	Diptera
Superfamily	:	Muscoidea
Family	:	Muscidae
Subfamily	:	Muscinae
Tribe	:	Muscini
Genus	:	*Musca*
Species	:	*domestica* (Nasif Nahle, 2006 & McLeod

et al, 2012)

2.1.4 Biology and Life Cycle of Housefly

The house fly belongs to super order Endopterygota as its wings develop internally during pupal stage and exhibits holometabolous metamorphosis by passing through all stages of insect development like egg, larva, pupa and adult. Its life is closely related to the availability of sufficient quantity of food and favorable temperature. A female house fly may lay 4-6 hatches and each hatch consists of 75-150 eggs. Eggs are deposited in crevices to save them from desiccation. Filthy food and garbage are the major breeding sites for house flies. In warm climatic conditions, house fly completes its life cycle from 2-3 weeks. It produces a large population at a rapid pace due to the large number of egg production and high rate of development. In a year, it may produce 10-12 generations in temperate region. But in contrast, they may produce 4-6 generations in cold regions where its breeding is limited to warmer months. Life span of adult housefly is about 15 to 30 days. Just on the day of their emergence, males are ready to mate but mating occurs when female is three days old. After few days of copulation, oviposition takes place(Iqbal *et al*, 2014).

2.1.4.1 Egg

Eggs are white in colour with pear shape having length of about 1-2 mm(Iqbal *et al*, 2014), is laid singly but eggs are piled in small groups. Each female fly can lay up to 500 eggs in several batches of 75 to 150 eggs over a three to four day period. Eggs are commonly laid in rotting garbage, organic matter, etc. The number of eggs produced is a function of female size which, itself, is principally a result of larval nutrition. Maximum egg production occurs at intermediate temperatures, 25 to 30°C. Often, several flies will deposit their eggs in close proximity, leading to large masses of larvae and pupae. Eggs must remain moist or they will not hatch (Sanchez-Arroyo *et al*, 2014). Just after oviposition, within a day eggs are hatched into larvae (maggots) (Iqbal *et al*, 2014).

2.1.4.2 Larva

After a week, the maggots (larvae) develop through three larval stages (instars) (Iqbal *et al*, 2014). Early instar larvae are 3 to 9 mm long, typical creamy whitish in color(Sanchez-Arroyo *et al*, 2014), saprophagus in nature (Iqbal *et al*, 2014) and cylindrical but tapering toward the head. The head contains one pair of dark hooks. The posterior spiracles are slightly raised and the spiracular openings are sinuous slits which are completely surrounded by an oval black border. The legless maggot emerges from the egg in warm weather within eight to 20 hours. Maggots immediately begin feeding on and developing in the material in which the egg was laid. The larva goes through three instars and a full-grown maggot, 7 to 12 mm long, has a greasy, cream-colored appearance.

High-moisture manure favors the survival of the house fly larva. The optimal temperature for larval development is 35 to 38°C, though larval survival is greatest at 17 to 32°C (Sanchez-Arroyo *et al*, 2014). They feed on dead and decaying organic material, such as garbage or feces (Iqbal *et al*, 2014). Nutrient-rich substrates such as animal manure provide an excellent developmental substrate.They live for 14 to 36 hours. After completion of their third instar, the maggot is full-grown, it can crawl up to 50 feet to a dry, cool place near breeding material and transform to the pupal stage (Sanchez-Arroyo *et al*, 2014).

2.1.4.3 Pupa

The pupal stage, about 8 mm long, is passed in a pupal case formed from the last larval skin which varies in color from yellow, red2, brown, to black as the pupa ages. The shape of the pupa is quite different from the larva, being bluntly rounded at both ends. Pupae complete their development in two to six days at 32 to 37°C, but require 17 to 27 days at about 14°C). The emerging fly escapes from the pupal case through the use of an alternately swelling and shrinking sac, called the ptilinum, on the front of its head which it uses like a pneumatic hammer to break throug the case (Sanchez-Arroyo *et al*, 2014).

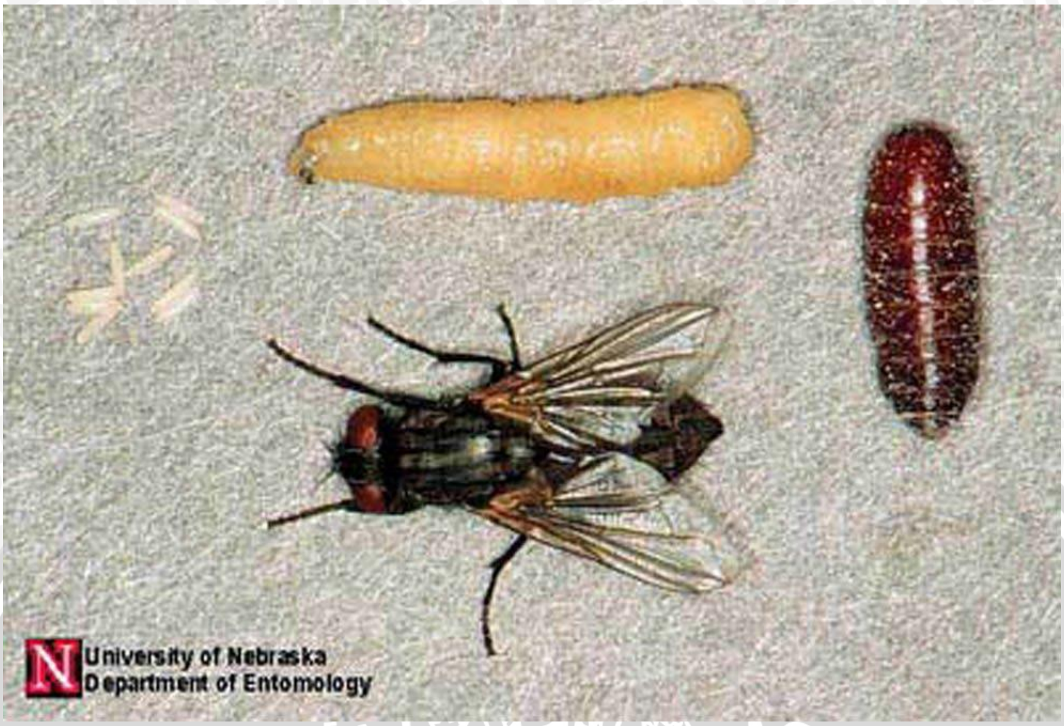

Figure 2.1 Life cycle of the house fly, *Musca domestica* Linnaeus.Clockwise from upper left: eggs, larva, pupa, adult (Sanchez-Arroyo *et al*, 2014).

2.1.5 Morphology of Adult Flies

The house fly is 6 to 7 mm long, with the female usually larger than the male. The female and can be distinguished from the male by the relatively wide space between the eyes (in males, the eyes almost touch). Adults usually live 15 to 25 days, but may live up to two months. Without food, they survive only about two to three days. Longevity is enhanced by availability of suitable food, especially sugar. Access to animal manure does not lengthen adult life and they live longer at cooler temperatures. They require food before they will copulate, and copulation is completed in as few as two minutes or as long as 15 minutes. Oviposition commences four to 20 days after copulation. Female flies need access to suitable food (protein) to allow them to produce eggs, and manure alone is not adequate. The potential reproductive capacity of flies is tremendous, but fortunately can never be realized. The flies are inactive at night, with ceilings, beams and overhead wires within buildings, trees, and shrubs, various kinds of outdoor wires, and grasses reported as overnight resting sites. In poultry ranches, the nighttime, outdoor aggregations of flies are found mainly in the branches, and shrubs, whereas almost all of the indoor populations generally aggregated in the ceiling area of poultry houses. Fruit and vegetable cull piles, partially incinerated garbage, and incompletely composted manure also are highly favored sites for breeding (Sanchez-Arroyo *et al*, 2014).

2.1.5.1 Head

The head of the adult fly has reddish-eyes and sponging mouthparts (Sanchez-Arroyo *et al*, 2014). They mouths are made up of two fleshy parts attached to their lower lip. The lips have grooves that are like channels for the liquid food they eat. Housefly larvae have hooks on their mouths which they use to eat bacteria (Jonelle D., 2013).

Figure 2.2 Lateral view of the head of an adult house fly, *Musca domestica* Linnaeus(Sanchez-Arroyo et al, 2014).

2.1.5.2 Antennae

Perception channels in houseflies include olfactory, tactile, vision, and chemical signals such as pheromones. Olfactory senses are used extensively to find food. Chemical sensations from their olfactory system create an electrophysiological response on the antennae. Researchers observe the electrical spikes in the stimulation of olfactory cells on their antennae to determine if the housefly under study is attracted or repelled by an odor. Humans have taken advantage of this trait, developing commercial repellents with odors they find unpleasant (Jonelle D., 2013).

The antennae contain three segments: a proximal scape, pedicel and distal flagellum. All antennal segments contain sensilla;however, the most numerous sensilla are concentrated on the flagellum.Antennae are considered to be the nostrils of insects. The sensitivity of chemoreceptive sensory neurons to odor varies and those that respond to a wide range of different chemicals are considered generalist cells. Different cells, even within the same sensillum, can exhibit different profiles of response to a range of chemicals. In regard to fly species of forensic importance, females are rapidly attracted to corpses emanating odors in the form of chemical cues of animal decomposition, including blood and/or wounds (Sukontasona *et al*, 2004).

2.1.5.3 Thorax

The thorax bears four narrow black stripes and there is a sharp upward bend in the fourth longitudinal wing vein (Sanchez-Arroyo *et al*, 2014). They only have one pair of translucent wings for flying and the second pair are only used for balance (Jonelle D., 2013).

2.1.5.4 Abdomen

The main part of their body, called their abdomen, is gray or yellowish with dark midline and irregular dark markings on the sides. The underside of the male is yellowish (Sanchez-Arroyo *et al*, 2014). Houseflies have dark gray or gray and yellow bodies with dark lines. The abdomen has 8 segments in males and 9 segments in females. Females have 5 segments of their abdomen visible all the time. She sticks out the other 4 when she lays her eggs. This way, she can lay eggs under the surface. Females are a little bit bigger than males (Jonelle D., 2013).

Figure 2.3 Adult house fly, *Musca domestica* Linnaeus (Sanchez-Arroyo *et al*, 2014).

2.1.6 Sensory Mechanism of fly

Sensory systems means touch, hearing, vision, taste, smell,map features of the external world into internal representations in the brain that ultimately allow all animals to navigate their environments. The olfactory system is capable of detecting an extremely large number of volatile chemical stimuli, possibly exceeding tens of thousands, although the total olfactory coding capacity of any animal has never been exhaustively catalogued. The ability to recognize such a vast number of odorous ligands is thought to be due to the special properties of the ORs, the large family of membrane proteins that is selectively expressed in OSNs in the olfactory epithelium of vertebrates and antennae of insects. ORs have selective but broad ligand binding properties, such that a given OR is activated by multiple odors and a given odor activates multiple ORs. This combinatorial coding strategy based on a large family of ORs with broad but selective ligand pharmacology in part accounts for the ability of animals to detect and discriminate a number of odors that far exceeds the number of ORs they possess. In all arthropods and vertebrates studied to date, the early olfactory system is organized into a large number of spherical neuropil elements, called glomeruli. Olfactory glomeruli represent points of convergence where olfactory sensory neurons (OSNs) expressing the same OR synapse with inhibitory local interneurons and secondary neurons that relay olfactory information to higher brain centers.The advanced state of knowledge concerning gene expression and synaptic organization of the early olfactory system of the fly makes this a compelling system to address questions in odor coding the olfactory system processes odors to produce stereotyped behavioral outputs (Laissue and Vosshall, 2008)

The olfactory and gustatory abilities of insects depend on many chemoreceptors and associated proteins encoded by at least four major gene families. The odorant binding proteins (OBPs) are small, globular, secreted proteins that transport hydrophobic odorants to the receptors in sensory neuron membranes within sensory sensilla, primarily on the antennae, but also on the maxillary palps and other chemosensory organs. The odorant receptors (ORs) are a relatively recently evolved family within the insect chemosensory superfamily of ligand-gated ion channels that mediate much of olfaction in insects. The gustatory receptors (GRs) mediate much of gustation, especially perception of sugars and bitter tasting compounds, but as the basal family of highly divergent receptors within the superfamily, also mediate some aspects of olfaction, such as perception of carbon dioxide. The ionotropic receptors (IRs) are a greatly expanded and divergent family of chemoreceptors that evolved from the ionotropic glutamate receptor superfamily in basal animals, and while some function in olfaction, many are involved in gustation. *M. domestica* genome encodes at least 87 OBPs and has the Odorant receptor coreceptor (OrCo) protein that functions with each specific OR to make a functional olfactory receptor(Scott *et al*, 2014).

Sensory organs called sensilla cover the tissues and Odorant Receptor Neurons (ORNs), which are dedicated to convert odorant signals into electrical outputs. Several molecular palyers have been involved in this transduction pathway (Takkenand Knols, 2010). Odorant molecules access the sensillum lumph throughout pores in the cuticles and are shuttled to a membrane protein complex constituted of a Sensory Neuron Membrane Protein (SNMP) and Odorant Receptor(OR) heteromer (ORxOR7).In Figure 2., the model of olfactory transduction, OR activation triggers two responses. The fast response involves a direct effect on the receptors, which act as an odorant-gated ion channel. A slower respone is mediated via a G protein(Gp) dependent secondary messenger pathway including Adenyl Cyclase (AC) and cyclic AMP (cAMP) (Takkenand Knols, 2010).

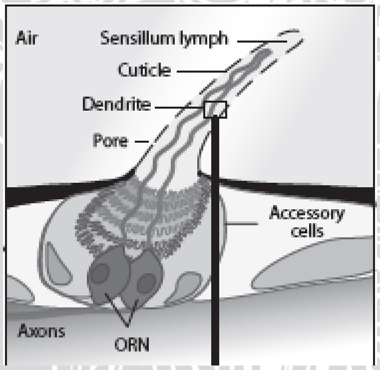

Figure 2.4 Olfactory sensillum (Takkenand Knols, 2010)

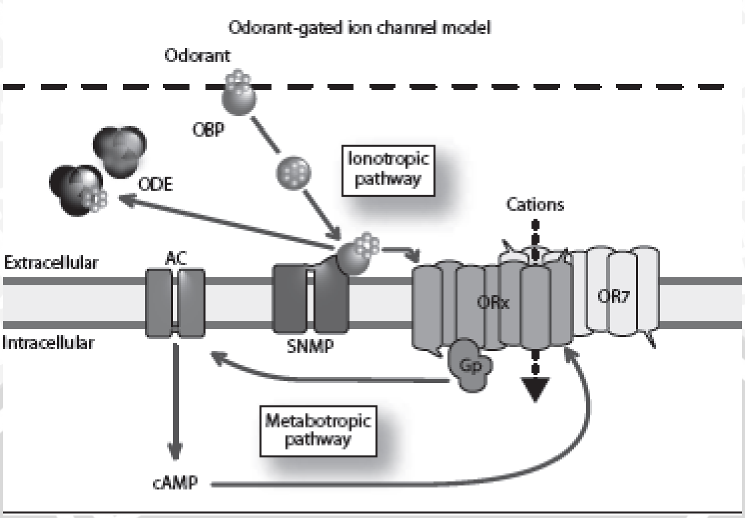

Figure 2.5 The model of olfactory transduction (Takkenand Knols, 2010)

2.1.7 Habitat

Houseflies live close to humans, in urban and rural areas. Because their larvae grow best in human garbage and feces, they are more common in urban areas. Their favorite environments are dung heaps, garbage cans, and roadkill. They also reproduce on rotted fruit and vegetables, old broth, boiled eggs, and even rubber.Houseflies live in temperate regions, meaning places that have seasons. They are most common in warm seasons, but some of them survive the winter. Their ideal temperatures are between 10 and 26.6 degrees Celsius. If it gets colder than 7.2 degrees Celsius, houseflies stop being active. If it gets less than 0 or above 44.4 degrees Celsius, they die. They are more likely to die from hot or cold when it's also very humid. Larvae are best able to survive between 30 and 35 degrees Celsius (Jonelle D., 2013).

2.1.8 Communication

Houseflies have senses of smell, touch, and sight, and also understand chemical signals like pheromones. Their sense of smell is located in their antennae and used to find food. Researchers measure the electricity in the smelling cells on their antennae to tell if a housefly is attracted to a smell or repelled by it. This is how they figure out how to repel flies with smells they don't like.Houseflies have taste hairs which they use to taste food, and many of them are in their feet. They have other hairs all over their bodies that feel air flow and help stop them from running into things while flying. They have compound eyes made up of many eye cells, and can see lights and motions.Houseflies are attracted to soil or feces that has chemicals in from other larvae called metabolites. These chemicals show that there are other larvae and nutrients there. This is used by females to decide where to lay their eggs (Jonelle D., 2013).

2.1.9 Damage and Medical Importance

Flies commonly develop in large numbers in poultry manure under caged hens, and this is a serious problem requiring control. Although this fly species does not bite, the control of *Musca domestica* is vital to human health and comfort in many areas of the world. The most important damage related with this insect is the annoyance and the indirect damage produced by the potential transmission of pathogens (viruses, bacteria, fungi, protozoa, and nematodes) associated with this fly. Pathogenic organisms are picked up by flies from garbage, sewage and other sources of filth, and then transferred on their mouthparts, through their vomitus, feces and contaminated external body parts to human and animal food. Of particular concern is the movement of flies from animal or human feces to food that will be eaten uncooked by humans. Also, when consumed by flies, some pathogens can be harbored in the mouthparts or alimentary canal for several days, and then be transmitted when flies defecate or regurgitate. In situations where plumbing is lacking, such as open latrines, serious health problems can develop, especially if there are outdoor food markets, hospitals, or slaughter houses nearby. Among the pathogens commonly transmitted by house flies are *Salmonella, Shigella, Campylobacter, Escherichia, Enterococcus, Chlamydia*, and many other species that cause illness. These flies are most commonly linked to outbreaks of diarrhea and shigellosis, but also are implicated in transmission of food poisoning, typhoid fever, dysentery, tuberculosis, anthrax, ophthalmia, and parasitic worms (Sanchez-Arroyo *et al*, 2014).

2.2 Repellent and its importance

Repellent is defined as substances that cause insect to turn away.Insect repellents are an alternative to the use of insecticides.They may be applied to the skin to protect an individual from annoying insects and from the bites of mosquitoes, mites, ticks and lice or, less commonly, may be used to exclude insects from an area, such as in packaging to prevent infestation of stored products (Peterson *et al*, 2001). Chemicals and poisonous substances are effective, but can bring harmful in the kitchen, around children and pets. One of the example of carcinogenic chemical that have been used which either repell or kill the flies is N,N-diethyl-3-methylbenzamide (DEET) (Fried and *et al*,2007). With increasing problems of insecticide resistance and increasing public concerns regarding pesticide safety, new, safer active ingredients are becoming necessary to replace existing compounds on the market. Furthermore, the use of repellents in an integrated pest management program has been used to a large extent. With the growing demand for environmentally sound strategies in the control of pests and insects, the development of alternative pesticides or repellents with minimal ecological hazards has now become an imperative need Natural pesticides are active substances such as home remedies or derived from plants and fruits are often used for pest management (Peterson *et al*, 2001).

2.3 Bay Leaf ***(Laurus nobilis*)**

2.3.1 Description

Bay leaf, *Laurus nobilis* (Lauraceae), is an evergreen shrub up to 2.15 m height and commonly named bay laurel. Bay leaf is widely used as a dried herb and gives a very fragrant and aromatic esse used as a valuable spice and flavoring agent in the culinary and food industries and as an additive in cosmetics and as an additive in cosmetics. Moreover, it is also widely used in folk medicine to treat gastrointestinal problems, rheumatism, diuretic, urinary problems and stones. Bay laurel grows at the edges of rivers, on mountains and on wet cliffs. It also grows in the humid and sub-humid bioclimatic areas.The biological activities of *L.nobilis* have been extensively investigated and indicated that *L. nobilis* could be used as botanical biopesticide in postharvest crop protection. *L. nobilis* essential oil has a repellent action, reduces fecundity, decreases egg hatchability, increases larval mortality and adversely influences offspring to insect (Jemâa *et al*, 2011).

Figure 2.6 Bay leaf (*Laurus nobilis*) (Grieve, 2014)

2.3.2 Taxonomical classification of Bay leaf

Kingdom : Plantae

Division : Magnolids

Order : Laurales

Family : Lauraceae

Genus : *Laurus*

Species : *Laurus nobilis* (Patraka *et al*, 2012)

2.3.3 Morphology

2.3.3.1 Flower

Mostly dioecious; the flowers are hidden in the foliage and are generally inconspicuous and individual flowers are small with white petals and males with yellow stamens lending an overall creamy white to yellow-white color to the flower clusters (Arnold, 2004).

2.3.3.2 Fruit

Fruits are roundish black berries which mature in fall; they are not particularly ornamental (Arnold, 2004).

2.3.3.3 Stem / Bark

Stems are medium to stout. There is strong apical dominance on vigorous stems.Stems are bright green and remain so for an extended time, eventually becoming splotched with gray and maturing to a gray-brown color,angled at first and then roundand glabrous. Buds are divergent; pointed to conical; prominently stalked; initially green, then maturing to a light to medium brown;The color of bark is gray to gray-brown (Arnold, 2004).

2.3.3.4 Leaves

The Leaves are generally 5 to 10 x 2 to 7.5 cm, and alternate, narrowly parallel-sided, lance-shaped, or pinched at both ends, smooth, margins undulate, glossy dark green above(Tucker, 2009).

2.3.4 Composition of Bay Leaf, *Laurus nobilis*

One of the main active constituents of bay leaf (*Laurus nobilis*) is 1,8-cineole. Other constituents include sesquiterpenes (costunolide and zaluzanin D), two guaianolides (dehydrocostus lactone and zaluzanin D), p-menthane hydroperoxides (including (1R,4S)-1-hydroperoxy-p-menth-2-en-8-ol acetate), costunolide, dehydrocostus lactone, reynosin, santamarine, 3alpha acetoxyeudesma-1,4(15), 11(13)-trien-12, 6alpha-+ ++olide, and 3-oxoeudesma-

1,4,11(13)-trien-12,6alpha-olide (Sigma-Aldrich, 2014). Chemically it has found to contain sesquiterpene lactones such as 10-epigazaniolide, Gazaniolide, spirafolide, costunolide, Reynosin, santamarine, flavonoid glycosides, essential oil (Patrakar *et al*, 2012) and lauric acid (Rudrappa, 2009-14). Essential oil from the bay leaves contains mostly cineol (50%); furthermore, *eugenol, chavicol, acetyl eugenol, methyl eugenol, α- and β-pinene, phellandrene, linalool, geraniol* and *terpineol* are also found (Rudrappa, 2009-14). And also have α-terpinyl acetate, terpinene-4- ol, α-pinene, β- pinene, *p*-cymene, linalool acetate. It also found to contain (*E*)-β-cymene, β-longipinene, cadinene, α-terpinyl acetate, α-bulnesene, terpinene-4-ol (4.25%), sabinene. The acyclic monoterpenes linalool and myrcenol were present in smaller amounts, while cumin aldehyde, dimethylstyrene, eugenol, methyl eugenol, and carvacrol were found (Patrakar *et al*, 2012).

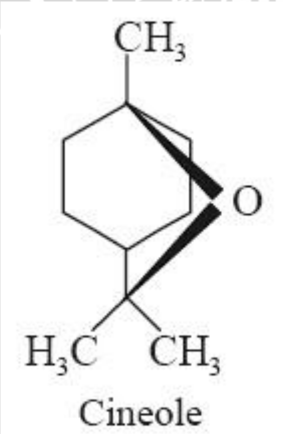

Figure 2.7 Structure of Cineole (Pharmacognosy, 2012)

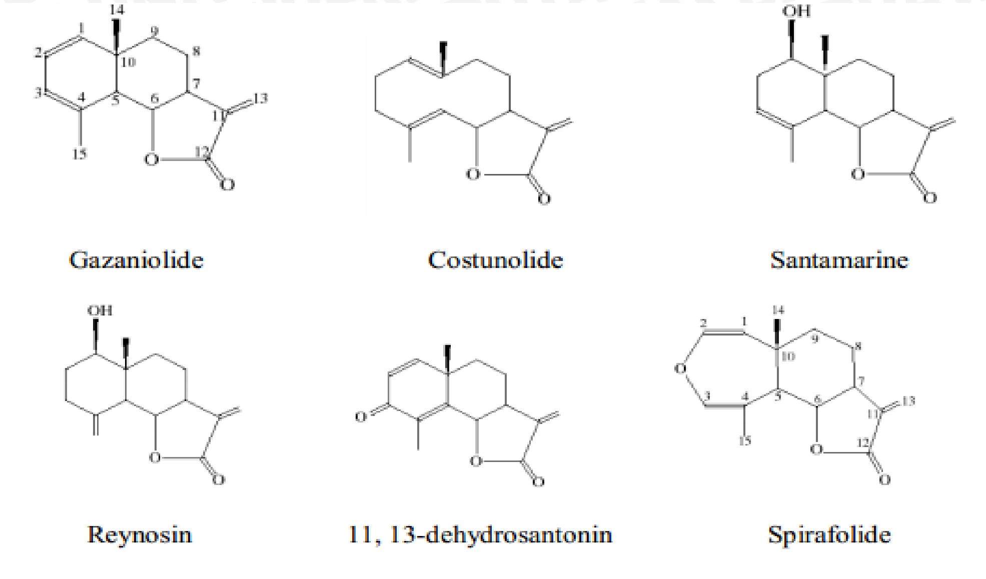

Fig. 2.8 Structures of some phytochemicals isolated from *Laurus nobilis* (Patrakar *et al*, 2012)

2.3.5 Uses of Bay Leaf (*Laurus nobilis*)

2.3.5.1 Culinary Uses

Bay leafs are spices and used in cooking due to their aroma (Moghtader and Salari,2012). Bay leaf is added at the beginning of cooking soups and stews and slowly imparts a deep, rich flavor. The leaf is left whole so it can be retrieved before serving the dish (Herb Society of America Fact Sheet, 1999). Furthermore, for cooking purposes, bay leaves are used almost exclusively as flavor agents during the food preparation stage; even when cooked (Moghtader and Salari, 2012).

2.3.5.2 Medicinal Uses

Bay laurel has been used as an antiseptic and a digestive (Herb Society of America Fact Sheet, 1999). Bay leaves also have been reported to possess wound healing, neuroprotective, antioxidant, antiulcerogenic, anticonvulsant, antimutagenic, antiviral, anticholinergic, antibacterial, antifungal activities (Patrakar *et al*, 2012). Moreover, supplementation with bay leaf extract in cases of infertility with varicocele may have a protective effect (Akunna *et al*, 2013). Bay leaf were also found to have different pharmacological properties including inhibitory effects on NO production (antiinflammatory) (Fang *et al* ,2004).

2.3.5.3 Uses and Effect of Bay Leaf as A Repellent

L. nobilis essential oil showed significant pest repellent activity (Jemâa *et al*, 2011). The lauric acid in the bay laurel leaves has insect repellent properties (Rudrappa, 2009-14). The biological activities of *L.nobilis* have been extensively investigated and indicated that *L. Nobilis* essential oil has a repellent action, reduces fecundity, decreases egg hatchability, increases larval mortality and adversely influences offspring to insect (Jemâa *et al*, 2011). In repellency bioassays, *L. nobilis* essential oil tested gave encouraging results against adults of *L. serricorne*. The oil showed strong repellent efficacy.Chi-square analysis indicated that *L. nobilis* essential oil showed significant pest repellent activity to *L. serricorne* adults. *L. nobilis* essential oil was repellent to the cigarette beetle species (Jemâa *et al*, 2011). Essential oil from the bay leaves contains mostly cineol (50%); furthermore, *eugenol, chavicol, acetyl eugenol, methyl eugenol, α- and β-pinene, phellandrene, linalool, geraniol* and *terpineol* are also found (Rudrappa, 2009-14). Essential oils are volatile, usually distillable liquid fractions responsible for the aroma of the plant. The vast majority of them are pleasant smell and its metabolic and evolutionary significance lies in the role they play as attractor of pollinating agents (for its pleasant aroma), constitute elements of defense against the attack of parasites, herbivorous animals and insects.Essential oil interfering with AchE are acting as potent of the central nervous system where all synapses cholinergic are virtually located of the cholinesterase inhibitors are known as anticolinesterasic, the chemical products that interfere with the action of this enzyme are potent neurotoxins (Leyva *et al*, 2012).