2.1. Reviews on Dental Plaque

Dental plaque is a soft tenacious deposit of complex microbial community compromised of bacteria and bacterial by-products which can be found on tooth surface like enamel and other hard substances consists of restorative materials, implants and prostheses (Reddy, 2008; Ehrlich and Schroeder, 2012). Dental plaque grows as biofilm and it has been recognized to be mostly responsible for development of dental caries and different forms of periodontal diseases (Samaranayake, 2002; Ehrlich and Schoereder, 2012).

A dental plaque biofilm is an accumulation of microorganisms which is highly-organized and enclosed in a slimy extracellular matrix that attaches to tooth surfaces (Nield, et al., 2003; Dumitrescu, 2010). It forms within hours or days and it may consist of a monolayer or layers of single or multiple species of microorganisms and also debris (Jass, et al., 2003; Bhowmik, et al., 2012).

The basic properties of biofilm are (Nield, et al., 2003):

1) Microorganisms are arranged in the form of attached mushroom-shaped microcolonies.

2) Microorganisms send chemical signals between bacterial microcolonies in order to have a basic communication system.
3) Each microcolony has a different community of microorganisms with its own customized living environment.

4) Microcolonies are enclosed by slimy extracellular layer to protect the bacteria within micro-colonies from antibiotic, antimicrobials and host defence mechanism.

5) Nutrients and metabolic movements of microorganisms within biofilm are facilitated by a series of fluid channels which penetrates the extracellular layer.

Based on its anatomical location and relationship to the gingival border, dental plaque can be categorized into supragingival and subgingival plaque (Reddy, 2008).

1) Supragingival plaque which is originated from salivary glycoprotein and salivary microorganisms can be further differentiated into coronal plaque (only on tooth enamel above the gingival margin) and marginal plaque (tooth surface at the gingival margin). It differs from grey to yellowish-grey to yellow and can be detected clinically only after a formation of definite thickness depending on the age, diet, host factors, oral hygiene, saliva, systemic diseases and teeth alignment. Nutrition supply is gained from saliva and consumed food (Reddy, 2008; Carranza, et al., 2011).

2) Subgingival plaque which is stimulated by bacterial growth of supragingival plaque can be further differentiated into tooth-associated and tissue-associated (epithelium and/or connective tissue). It is usually thin and can be detected below the gingival margin between the tooth and gingival sulcular tissue.
Subgingival plaque can be only discovered by performing probing around the gingival margin (Carranza, *et al.*, 2011). The source of the nutrients is commonly derived from the gingival crevicular fluid, exudate and leukocytes (Bathla, 2012).

### 2.1.1 Composition of Dental Plaque

Composition of dental plaque mainly consists of 70-80% bacterial microorganisms. One gram of plaque will approximately contain about $2 \times 10^{11}$ bacteria. It is also composed of non-bacterial microorganisms like yeast, protozoa, viruses and mycoplasma species. A few host cells present too such as leukocytes, macrophages and epithelial cells (Narayanaswamy, 2007; Carranza, *et al.*, 2011). According to Reddy (2008), the material that exists among the microorganisms is known as intermicrobial matrix which consists of organic and inorganic materials originated from saliva, gingival crevicular fluid and bacterial products.

The organic components of the matrix which present are polysaccharides, proteins, glycoproteins, lipid substance and maybe DNA. Polysaccharides compound (carbohydrates) is mainly produced by the existing microorganisms in the form of levans (fructans) which primarily provides energy and glucans (dextans) is responsible for not only energy supply whereas to maintain the integrity and structure of the dental plaque biofilm. Besides that, other carbohydrates are also present like galactose and rhamnose. Proteins in the form of albumin are most probably derived from gingival crevicular fluid while glycoproteins are originated from saliva. The lipid substance composed of debris
from the disruption of the bacterial membrane and host cells and perhaps food debris too (Reddy, 2008; Rajesndran, 2009; Carranza, et al., 2011).

The inorganic components of the matrix are mostly calcium and phosphorus with a small amount of magnesium, sodium, potassium and fluoride (Narayanaswamy, 2007; Reddy, 2008). The inorganic components of supragingival plaque originated predominantly from saliva. Higher concentration of mineral contents results in calcification of plaque mass to form calculus. The source of the inorganic constituents of subgingival plaque is mainly from crevicular fluid in the form of serum transudate. Similar to supragingival plaque, subgingival plaque calcification also leads to the formation of calculus (Narayanaswamy, 2007; Carranza, et al., 2011).

### 2.1.2 Mechanism of Plaque Formation

Dental plaque can be found on tooth surface within one to two days without any oral hygiene conducts. Plaque can be noticed as whitish, greyish or yellowish and usually accumulates in the cracks, pits, fissures on tooth surface, below overhanging restorations and misaligned teeth (Haake, et al., 2002; Narayanaswamy, 2007).

The mechanism of dental plaque formation can be divided into 3 stages (Marya, 2011):

1) **Formation of dental pellicle on the tooth surface**

As soon as professional cleaning is done on tooth surface, proteins and glycoproteins are adsorbed resulting in the formation of conditioning film which
is called as acquired enamel pellicle (Marsh and Martin, 1999; Nield, et al., 2003). All the surfaces in the oral cavity including teeth, tissues, fixed and removable restorations will be coated with the pellicle. The pellicle components are derived from saliva, gingival crevicular fluid, bacterial and bacterial by-products, host tissues cell products and debris. This pellicle functions as a protective layer for enamel from acid erosion and has a lubricant to wet the surfaces and prevent tissue dehydration. In addition to that, pellicle is like double-sided sellotape, where one side, it attaches to the tooth surface while on the other side, it allows bacterial adhesion but not directly on the tooth surface (Samarayanake, 2002; Nield, et al., 2003, Narayanaswamy, 2007). Acquired enamel pellicle formation includes a few mechanisms like electrostatic forces, hydrophobic forces and van der Walls force. The hydroxyapatite surface composed of phosphate group which is negatively charged will interact with positively charged components of saliva and gingival crevicular fluid (Haake, et al., 2002; Narayanaswamy, 2007).

2) Initial colonization of bacteria

Within a few hours after formation of pellicle, bacteria begin to attach on the outer surface of the pellicle. Initially colonizing bacteria are predominantly by Gram-positive facultative bacteria such as Actinomyces viscosus and Streptococcus sanguis (Nield, et al., 2003, Narayanaswamy, 2007). The presence of specific adhesins on the bacterial cell surface, commonly protein, aids the bacterial attachment process onto the pellicle by interacting with the complementary receptors of the acquired pellicle which consists of protein, glycoproteins or polysaccharides (Carranza, et al., 2011).
3) Secondary colonization and maturation of bacteria

Subsequently, secondary colonizers such as *Prevotella gingivalis*, *Prevotella intermedia*, *Prevotella loescheii*, *Capnocytophaga* spp. and *Fusobacterium nucleatum* which have a very poor ability of adhering directly to a clean tooth surface are found attached onto the primarily attached bacteria. This process of new bacterial colonizer adherence to the primarily attached bacteria is known as coaggregation or coadhesion. It frequently involves the interaction of proteins (usually lectins) and complementary receptors (carbohydrates) (Nield, *et al.*, 2003; Bathla, 2012). During plaque maturation, *Fusobacterium nucleatum* is recognized to be essential in bridging between primary and secondary bacterial colonizers. Bridging means two non-aggregating strains get involved in a multi generic aggregate when they detect a mutual partner in a distinct mechanism. For examples of interactions between initial colonizer and secondary colonizer are *Fusobacterium nucleatum* and *Streptococcus sanguis* and *Prevotella loescheii* and *Actinomyces viscosus*. As examples of interactions among secondary colonizers are *Fusobacterium nucleatum* with *Prevotella gingivalis* and *Fusobacterium nucleatum* with *Treponema denticola* (Carranza *et al.*, 2011; Bathla, 2012). There will be a major transition of primarily and facultative anaerobic organisms during the early phase into a phase of completely facultative and obligate anaerobic species.
2.1.3 Correlation between Dental Plaque and Periodontal Disease

Dental plaque has been recognized as one of the main causative agents which initiate the development of periodontal disease (Soames and Southam, 2005). Periodontal diseases are inflammations of the periodontium tissues that support the tooth in its surrounding bony socket but generally refer to inflammatory diseases which are plaque-induced gingivitis and periodontitis. Periodontium tissues consist of gingiva, the alveolar bone of the jaw, the cementum of the root surface and the periodontal ligament (Hillson, 1996; Strohm and Alt, 1998).

The initial stage of periodontal diseases after plaque accumulation is called as gingivitis (Schluger et al., 1977). It may just be limited to an inflammation of the soft gum tissues and commonly characterised by increased flow of gingival crevicular fluid (GCF), loss of stippling, redness, swollen gum and bleeding during tooth brushing, flossing or upon gingiva probing. The later serious stage of periodontal diseases is known as periodontitis when the gingival inflammation advances to the underlying bone and starts to damage and destroy the periodontal ligament and the alveolar bone (Molnar and Molnar, 1985; Soames and Southam, 2005). It includes the characteristics of bright red swollen gums that are very tender when touched and gums can pull away from the teeth with some new space between them. It can result in tooth mobility and tooth loss due to the bone resorption and destruction of periodontal ligament. However, tooth loss does not occur all the time, the severity of periodontitis differs with cases as the progression of alveolar bone destruction is also unpredictable,
interchanging between periods of resorption and remission. Gingivitis is always preceded by dental plaque accumulation, however not all gingivitis develops to periodontitis (Narayanaswamy, 2007).

There are a number of different plaque hypothesis. According to Walter Loesche (1976) who generated non-specific plaque hypothesis, periodontal disease is the final outcome of toxin production by the whole plaque microflora. However, the flaws of this hypothesis were that certain individuals with all the time existing amount of plaque and calculus never advanced into destructive periodontitis and several sites were not affected while advanced disease was discovered in the nearby sites (Fejerskov and Kidd, 2008; Reddy, 2008).

On the other hand, specific plaque hypothesis generates that only selected plaque is pathogenic and the severity of its pathogenicity depends on the presence or increase of that particular species. The shortcoming of this hypothesis was discovery of the virulent pathogen without the evidence of disease or absence of the specific pathogen in the diagnosis of the disease (Fejerskov and Kidd, 2008; Carranza et al., 2011). Then there was a modern version of the specific theory which was defined in 1979 by Socransky. This theory postulates that 6-12 of different bacterial species can be accountable for most of the destructive periodontitis cases whereas additional species may cause smaller amount of other cases (Carranza et al., 2011; Bathla, 2012).

Lastly, Thelaide (1986) proposed the modern version of non-specific and specific plaque hypothesis known as unified theory. As stated in this theory, whole bacterial plaque may be responsible for its potential pathogenicity due to its
capacity of colonizing and invading the host defence mechanism and induce inflammation and tissue destruction (Bathla, 2012).

The exact mechanism by how dental plaque advances into periodontal diseases is remaining unknown but it has been proven that more than 300 species microorganisms have been derived from periodontal pockets and Gram-negative anaerobic microorganisms being the most commonly isolated microorganism from active periodontal destruction. These microorganisms adhere as biofilm and the metabolic interaction and synergism between the microorganisms may contribute to the initiation and propagation process of attachment loss of the periodontal ligament which usually attaches the gingiva and the alveolar bone to the cementum on the root of the tooth (Hildebolt and Molnar, 1991). They have the capacity of invading the host defence mechanism and exposing the periodontium tissues to the noxious bacterial products. Periodontium tissues depend on certain host defence mechanisms which consist of polymorphonuclear neutrophils (PMNs), the complement system, the cellular and humoral immune reactions and various chemical mediators of inflammation (Dumitrescu, 2010). In response, host cells such as monocytes and fibroblasts are provoked to release cytokines by bacterial products like lipopolysaccharides (LPS). Cytokines are highly potent chemical messengers which responsible to stimulate inflammatory reactions and catabolic processes of bone resorption and collagen destruction through enzymes termed as matrix metalloproteinase (MMPs).

Moreover, as a response to plaque build-up, gingival crevicular fluid (GCF) which is neutrophil-rich transudate infuses via junctional epithelium to
neutralize possible pathogenic agents through phagocytosis. Dysfunction of neutrophils has been identified to be responsible for progression of different types of periodontal diseases. Lysosomes (cytoplasmic organelles) which can be found within the neutrophils possess enzymes consists of elastase and collagenase. The enzymes have the ability to metabolize bacterial by-products plus they might be also released into gingival tissues resulting in localised periodontium tissue damage and destruction.

2.1.4. Management of Dental Plaque

The gingival inflammation in general subsides and the gingiva tends to return to its normally healthy condition (Albandar and Rams, 2002). Thus, there is a need for management of dental plaque. Management of dental plaque or plaque control refers to the removal techniques of microbial plaque plus the prevention of its accumulation and recurrence on the teeth and the adjacent gingival surface (Vijay, 2002).

There are some methods on plaque management (Gillespie, 2006):

1) **Oral Hygiene Instruction (OHI)**

This may involve participations of a dentist to offer sufficient instructions for homecare. A dentist must be able to (Felton, 2009):

(1) Motivate the patients in order to change patients’ behavioural towards dental health and oral hygiene.

(2) Show practical demonstration on how to use disclosing solution.
(3) Guide patients on the most appropriate toothbrush and suitable tooth brushing method.

(4) Demonstrate on how to perform interdental cleaning like flossing.

2) Mechanical Plaque Control

Removal of dental plaque mechanically includes team approach between a professional personnel and the discipline of the patient. It consists of tooth brushing and interdental cleaning using oral hygiene aids (dental floss, interproximal brushes and wedge stimulators) and professional help for subgingival plaque removal (scaling, polishing and root planning) (Marya, 2011). Tooth brushing should be minimally carried out twice per day, in the morning and before sleeping at night. Individuals should follow proper tooth brushing principles like the correct method, duration and frequency of tooth brushing as well as type of tooth brush in preventing recession of gingiva, abrasion in the cervical areas of teeth, trauma and ulcerations on gingiva (Vijay, 2002).

Plaque control by mechanical is time-consuming and requires self-motivation which many individuals do not possess, thus there are many therapeutic chemical agents used as plaque control.

3) Chemical Plaque Control

The use of chemical agents like mouthwash as an addition to mechanical plaque control has a significant importance to reduce plaque accumulation. Lately, researches have been conducted to determine the suitable chemical agent to be added into mouthwash which may help to reduce plaque accumulation
The ideal antiplaque mouthwash should have the characteristics of (Nield, et al., 2003; Greenwood, 2009).

1. Inhibiting and destroying periodontal pathogens only
2. Preventing development of bacterial resistance
3. Presence of substantivity
4. Nontoxic on the local tissues and systemically
5. Reducing plaque and gingivitis significantly
6. Inhibiting the calcification process of plaque
7. Not causing teeth discolouration or taste alteration
8. No side effects on teeth and dental materials
9. Convenient in use and inexpensive

The common plaque-inhibiting agents are usually classified according to the groups of anionic surfactants, cationic surfactants, enzymes, heavy metal salts, herbal extracts and phenolic compounds. In general, it has been suggested to use mouthwash twice daily (morning and night) as an ideal practice in controlling plaque accumulation (Dumitrescu, 2011).

2.2 Holy Basil

_Ocimum tenuiflorum_ L. (used to be known as _Ocimum sanctum_ L.) traditionally known as Tulsi with its enormous medical significance is marked as Queen of herbs of Indian community for it has been used for thousand years in Ayurveda which is considered as the basis of all the medical sciences. Holy basil
is a sacred plant for Hindus and it is usually worshipped at homes and temples. It plays an important role in the holistic health of traditional Ayurvedic and Unani system and East system of herbal medicine (Maimes, 2004; Pattanayak, et al., 2010). Holy basil grows in India, Malaysia, Australia, Central and South America, western Asia and Puerto Rico in abundance. Holy basil used in the purpose of medicinal, religious, and culinary in Asia, China, the Middle East, North Africa and Australia has been documented (Maimes, 2004). Traditionally holy basils are consumed in various ways as herbal tea, dried powder or fresh leaf. Nowadays holy basils are being cultivated commercially for its essential oil.

Figure 2.1 Holy Basil (Joshi, et al., 2012)

*Ocimum tenuiflorum* L. can be propagated by seeds and usually grown in temples. It is an erect softy hairy herbaceous plant, sub-shrub with the height of 30-75 cm. The botanical description of holy basil consists of the root, stem, leaf, flower, fruit and seed. The thin root is branched, soft, wiry, externally greenish brown coloured and internally pale blackish coloured. The stem can be identified
as fractured, fibrous, woody, subquadrangular, slightly aromatic, greenish externally and cream coloured internally. The green type of *Ocimum tenuiflorum* L. leaves can be seen as extipulate (a leaf without stipules), grow in opposite direction and have thin and slender petioles. They are elliptic-oblong in 5-6 cm length and 2.5-3 cm breadth. The leaves have acute or obtuse leaf apex, bluntly serrated margins, pubescent (hairy surface) on both the sides, bright green with veins of upper surface and minutely gland-dotted on the lower surface. They are highly aromatic and have a pungent taste. The flowers are purple or crimson coloured, grow in elongate racemes and small enclose whorls. They are also hairy, strongly aromatic and taste pungent. The fruit contains 4 small sub-globosed or broadly elliptic nutlets. They are either pale brown or reddish in colour which are aromatic and taste pungent too. The seed can be recognised as 0.1 cm long and rounded to oval in shape. There is no odour, taste pungent and faintly sticky and moist (Pattanayak, *et al.*, 2010; Singh, *et al.*, 2011; Joshi, *et al.*, 2012).

The scientific and taxonomy classification of holy basil is:

- **Kingdom**: *Plantae*
- **Division**: *Tracheophyta*
- **Class**: *Magnoliopsida*
- **Order**: *Lamiales*
- **Family**: *Lamiaceae*
- **Genus**: *Ocimum* L.
- **Species**: *Ocimum tenuiflorum* L.
- **Local name**: *Kemangi*
2.2.1 The Phytochemicals Compounds of Holy Basil

The phytochemicals compounds of holy basil is greatly complex which consist of many nutrients and other active constituents where the proportions varies depending upon different soil, differing methods of cultivating, harvesting, processing and storage condition which are not well documented yet. The synergistic interactions of differing phytochemical compounds contribute to the nutritional, medicinal and pharmacological effects of traditionally used herb (Pattanayak, et al., 2010; Rahman et al., 2011).

The essential oil of the leaf mainly contains of eugenol, euginal (also recognized as euginic acid), ursolic acid or commonly known as a natural pentacyclic triterpenoid carboxylic acid, carvacrol, linalool, limatrol, caryophyllene and methyl carvicol or also identified as Estragol. The volatile oil of the seed consists of fatty acids and sitosterol. Furthermore, mucilage of the seed possess some amounts of sugars composed of xylose and polysaccharides while the green leaves contain anthocyanins (Kelm et al., 2000; Pattanayak et al., 2010; Rahman et al., 2011).

Figure 2.2 (a) Eugenol (b) Ursolic acid (c) Carvacrol (Rahman et al., 2011)
The stem and leaves of holy basil contain compounds which produce different biological activities such as saponins, flavonoids, triterpenoids and tannins (Jaggi et al., 2003). Two water-soluble flavonoids, Orientin and Vicenin, produce protection for human blood lymphocytes against radiation-induced chromosomal damage. Moreover, phenolic constituents exhibit antioxidant and anti-inflammatory properties like rosmarinic acid, propanoic acid, apigenin, cirsimaritin, isothymusin and isothymonin are also present. Even though holy basil is a general vitalizer and increases the level of physical endurance, it contains no caffeine or any other stimulants (Pattanayak et al., 2010).
The nutritional values of holy basils are vitamin A and C, and minerals like calcium, zinc and iron, as well as chlorophyll.

2.2.2 Benefits of Holy Basils Related to Body Systems

All parts of holy basil plant including leaves, flowers, stem, root and seeds have been identified to contribute to its therapeutic properties by traditional practitioners and modern scientific research plus it been introduced into modern medicine to treat various human body systems (Sethi et al., 2003; Maimes, 2004).

*Ocimum tenuiflorum* L. is beneficial to cardiovascular-circulatory system which consists of heart, blood and circulation. It prevents cardiac arrests, stabilizes blood pressure and provides vascular protection where it protects the heart and blood vessels in order to have even circulation and reduces bad cholesterol. Moreover, it also protects blood cells from the damage of foreign toxin like industrial chemicals. In the aspect of Ayurveda, Tulsi tea or infusion normalizes blood pressure and produces warming effects for the heart (Maimes, 2004; Pattanayak et al., 2010).

Furthermore, holy basil is also useful for digestive system which is composed of esophagus, stomach, intestine, liver and pancreas. It acts as a liver support and protective to improve the metabolic breakdown and eliminate dangerous chemicals from the blood. Holy basil has the potential to inhibit the growth of E. coli. Besides that, *Ocimum tenuiflorum* L. also serve as anti-diabetic, anti-helminthic, anti-ulcer activity and taking Tulsi tea or infusion with dried ginger in Ayurveda helps in indigestion (Maimes, 2004; Rahman et al., 2011).
In the aspect of endocrine system, holy basils help to reduce stress and increase stamina level and adaptive effects. In addition to that, it is beneficial for the immune system too. Holy basils increase cell-mediated immunity in the number of defence cells and T-cell activity. As an anti-inflammatory agent, it reduces the pain and inflammation as well as it does not irritate the stomach like aspirin and ibuprofen. Moreover, it is proven as antiviral in viral hepatitis and viral encephalitis cases. It decreases oxidative stress as an antioxidant. Holy basil aids in the management of immunological disorders such as allergies and asthma in the form of anti-allergic. In addition to that, holy basil primarily provides antibacterial, antiviral and antifungal effects, thus it is very helpful in handling major systemic diseases along with localized infections. As a cure for conjunctivitis in Ayurveda management, holy basil juice can be mixed with honey in order to be used as eyewash (Maimes, 2004; Pattanayak et al., 2010).

In addition to that, benefits of holy basils in the skin system are reduction of eczema, psoriasis and as antiseptic agent for wound healing as well as antibiotic protection. Holy basil provides anti-arthritic activity for the muscular system. Additionally, it is helpful to sharpen memory and serve as antipyretic agent. The Imperial Malarial Conference in 1909 has declared that *Ocimum tenuiflorum* L. is a true cure for malaria (Maimes, 2004; Rahman et al., 2011). In the field of Ayurveda, the oil of holy basil for ear infections or pain and in the case of periodic fevers, fresh juice of holy basil can be taken with black pepper powder.
2.2.3 Benefits of Holy Basils Related to Dental Health

During the formation and accumulation of dental plaque in addition to dental caries, *Streptococcus mutans* has been identified as one the primary contributing agents. The specific properties of *S. mutans* in producing acid and ability to synthesize glucans from dietary sucrose by glucosyltransferases (GTFs) lead to development and establishment of biofilm formation that is responsible for dental plaque propagation. Eugenol as the major compound of holy basils has shown antibacterial effect against *S. mutans* and *S. aereus*. The hydrophobicity property of eugenol permit them to penetrate the lipopolysaccharide of the bacterial cell membrane thereby disrupt the cell structures. Thus it inhibits synthesize of glucan which enables the adherence of cariogenic pathogens on tooth surface (Burt, 2004). Most of the other compounds like caryophyllene and ursolic acid have also been demonstrated to contain antimicrobial properties but not as potent as eugenol (Dorman *et al*., 2000).

Besides that, *Streptococcus sobrinus* has also been identified as to be responsible in plaque formation. Kim and his co-workers have proved that ursolic acid can inhibit the progression of *S. sobrinus*; therefore it can be used to develop in oral hygiene products. Furthermore, extract gel of holy basil has shown to accelerate wound healing process by increasing the level of macrophage and fibroblast production after tooth extraction. In addition to that, *Ocimum tenuiflorum* L. is also well known for protection and prevention from mouth as well as dental infection. A few fresh leaves chewed are seen effective and cures ulcer and infections in the oral cavity. In the case of teeth disorders, powdered
form of holy basils can be used for brushing teeth and it can also be mixed with mustered oil in order to make natural toothpaste. It has been proven in maintaining dental hygiene as well as health, diminishes bad breath and for massaging the gums (Chaudhary *et al.*, 2005; Singh *et al.*, 2012).

### 2.2.4 Precautionary of Holy Basil: Contraindications and Safety

Holy basils have been medicinally used for many years now especially in India but there is no documented safety indications on holy basils yet. However, traditional and modern practitioners find it as a very much safe healing herb and synergistic with other herbs. For an example, in USA, holy basil is available as a dietary supplement under the Dietary Supplement Health and Education Act of 1994 (DSHEA). Furthermore, holy basil is on the general sales list in UK whereas in Canada, it has been approved as the over-the-counter drug. In France, it has been accepted as traditional medicine (Maimes, 2004; Rahman *et al.*, 2011).

The precautions would be holy basil is not suggested for therapeutic benefits in pregnant women or during lactation period as well as to infants or toddlers. Although it has not been reported to have effects on human but there are studies that shows mild anti-fertility effects on animals (Seth *et al.*, 1981; Kasinathan *et al.*, 1972). Since holy basils have demonstrated to reduce blood glucose level as an anti-diabetic agent, hypoglycemic patients should have precautionary measures against holy basil products (Maimes, 2004).

As a conclusion, holy basil has been practically proven safe for people of all ages among the Indian community as it is usually consumed traditionally like
herbal tea, dried powder or fresh leaf. Furthermore, nowadays there are many products of holy basil being marketed internationally and being consumed by the public. In addition to that, the different species of basil which is known as ‘Daun kemangi’ in Indonesia is typically used for eating purpose and recognized as *lalapan* (Backer, *et al*., 1963). It is ordinarily sold in market in abundance.