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Phytochemical and Biopharmaceutical Aspects of *Psidium guajava* (L.) Essential Oil: A Review

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ABSTRACT

Essential oils distilled from aromatic and medicinal plants have been used both cosmetically and therapeutically. Nowadays, *Psidium guajava* L. plant parts are commonly used as medicinal plant. Although, there is considerable anecdotal information about the biological activity of guava essential oils much of this has not been substantiated by scientific evidence. Among the claims made for *Psidium guajava* (L.) essential oil is that have antimicrobial, antinociceptive, repellent, insecticidal, anticancer and anti-inflammatory effects. In this study we detail the current state of knowledge about the effect of guava essential oils and phytochemicals.

Key words: *Psidium guajava* L., essential oil, phytochemicals, anticancer activity, antimicrobial activity, insecticidal activity, anti-inflammatory effect

INTRODUCTION

Many complementary and alternative medicines have enjoyed increased popularity in recent decades. Essential oils are valuable natural products used as raw materials in many fields, including perfumes, cosmetics, aromatherapy, phytotherapy, spices and nutrition (Buchbauer, 2000). Aromatherapy is the therapeutic use of fragrances or at least mere volatiles to cure mitigate or prevent diseases, infections and indispositions by means of inhalation (Buchbauer *et al.*, 1993). This has recently attracted the attention of many scientists and encouraged them to screen plants to study the biological activities of their oils from chemical and pharmacological investigations to therapeutic aspects.

Psidium guajava L. (Myrtaceae) is one of such plants in folk medicine that has been used for the management of various disease conditions and is believed to active. Various parts of the plant has been used in traditional medicine to manage conditions like malaria, gastroenteritis, vomiting, diarrhoea, dysentery, wounds, ulcers, toothache, coughs, sore throat, inflamed gums and a number of other conditions (Jaiarj *et al.*, 1999; Abdelrahim *et al.*, 2002; Lutterodt, 1989). It has a long history of folk medicinal uses in Egypt and worldwide as a cough sedative, an anti-diarrheic, in the management of hypertension, obesity and in the control of diabetes mellitus (Karawya *et al.*, 1999; Abdelrahim *et al.*, 2002; Begum *et al.*, 2004; Morales *et al.*, 1994; Sunagawa *et al.*, 2004; Tanaka *et al.*, 1992). The leaf extract was found to possess anticestodal (Tangpu and Yadav, 2006), analgesic, anti-inflammatory properties (Ojewole, 2006), antimicrobial (Roy *et al.*, 2006) hepatoprotective (Chen *et al.*, 2006) and antioxidant activities (Nair and Chanda, 2007). In addition, the leaf extract is used in many pharmaceutical preparations as a cough sedative. The extracts contain flavonoids, mainly quercetin derivatives, which are hydrolyzed in the body to give the aglycone quercetin which is responsible for the spasmolytic activity of the leaves (Morales *et al.*, 1994). Quercetin has several pharmacologic actions; it inhibits the intestinal movement, reduces capillary permeability in the abdominal cavity (Zhang *et al.*, 2003) and possesses dose-dependent antioxidant properties (Nakamura *et al.*, 2000), anti-inflammatory activity (Havsteen, 1983; Middleton and Drzewieki, 1984, 1985; Amella *et al.*, 1985; Pearce *et al.*,1984; Busse *et al.*, 1984; Yoshimoto *et al.*, 1983) antiviral and antitumor activities (Murray and Pizzorno, 1999; Mucsi and Pragai, 1985; Kaul *et al.*, 1985; Farkas *et al.*, 1982; Guttner *et al.*, 1982; Kaneuchi *et al.*, 2003). This study, is aimed primarily at summarizing the phytochemical study and the bioactivity of essential oil from *Psidium guajava* L. (Guava) as potential biological and pharmacological agent. Hopefully, this will lead to new information on this plant application and new perspective on the potential use of guava essential oil.

Description of *Psidium guajava* L.: It is a small branched tree, bark smooth, mottled, peeling. Young stems angled. Leaves arranged in opposite, 6 inches long by 3 inches wide, aromatic, lateral veins on underside prominent. Flowers white (Fig. 2), one or more in leaf axils, many stamens. Fruits yellow (Fig. 1), 4 inches diameter, with pink flesh. Seeds tan colored, hard, many. Fruit used commercially to makes jams and drinks. In Latin America, the rind is canned as a dessert fruit. Guava is of tropical American origin, it is now widely distributed throughout the tropics. It is a weed of pastures and forests (Motooka *et al.*, 2003).

Scientific classification

Kingdom	:	Plantae
Order	:	Myrtales
Family	:	Myrtaceae
Subfamily	:	Myrtoideae
Genus	:	*Psidium*
Species	:	*guajava*
Binomial name	:	*Psidium guajava* L.

Fig. 1: *Psidium guajava* L. leaf and fruit

Fig. 2: *Psidium guajava* L. flower

Chemical constituents of Guava essential oil: Analysis of chemical constituents of essential oils is generally performed using GC (quantitative analysis) and GC-MS (qualitative analysis). Identification of the main component is carried out by the comparison of both the GC retention times and MS data against those of the reference standards (with known source); as previously reported (Lahlou *et al.,* 2001a, b; Lahlou and Berrada, 2003).

The fruit: The Guava fruit (Fig. 1) contain number of vitamins minerals and essential oil. Quite a few reports have been published covering the volatile compounds of guava fruits (Jordan *et al.*, 2003; Pino *et al.*, 2001a, 2002; Paniandy *et al.*, 2000; Yen and Lin, 1999; Chyau *et al.*, 1992; Yen *et al.*, 1992; Ekundayo *et al.*, 1991; Vernin *et al.*, 1991; Nishimura *et al.*, 1989; Chyau and Wu, 1989; Hashinaga *et al.*, 1987; Idstein and Schreier, 1985; MacLeod and Troconis, 1982; Wilson and Shaw, 1978; Stevens *et al.*, 1970). However, there are few studies on the sensory significance of volatile constituents in guava fruits. One of early reports concerning the volatile components in guava was given by MacLeod and Troconis (1982), who described that the mixture of 2-methylpropyl acetate, hexyl acetate, benzaldehyde, ethyl decanoate, β-caryophyllene and α-selinene had a guavalike aroma among 40 volatile compounds identified in guavas from Venezuela. Pino *et al.* (2001b) identified 204 compounds out of the aroma concentrate of strawberry guava fruits, of which ethanol, α-pinene, (Z)-3-hexenol, (E)-β-caryophyllene and hexadecanoic acid were the major constituents. The presence of many aliphatic esters and terpenic compounds is thought to contribute to the unique flavor of the guava fruits. Pino *et al.* (2002) also characterized 173 volatile components in Costa Rican guava and sensorily characterized them by GC-sniffing. The major constituents were β-caryophyllene, α-terpineol, α-pinene, α-selinene, β-selinene, δ-cadinene, 4,11-selinadiene and α-copaene. Again the amounts of aliphatic esters and terpenic compounds were thought to contribute to the unique flavor of this fruit. Jordan *et al.* (2003) studied the aromatic profile in commercial guavas and identified a total of 51 components as the principal components in guava essence and fresh fruit puree by GC-MS. In the olfactometric analyses, totals of 43 and 48 aroma active components were detected by the panelists in commercial essence and fruit puree, respectively. Principal differences between the aromas of the commercial guava essence and the fresh fruit puree could be related to the presence of acetic acid, 3-hydroxy-2-butanone, 3-methyl-1-butanol, 2,3-butanediol, 3-methylbutanoic acid, (Z)-3-hexen-1-ol, 6-methyl-

5-hepten-2-one, limonene, octanol, ethyl octanoate, 3-phenylpropanol, cinnamyl alcohol, α-copaene and an unknown component. (E)-2-hexenal seems more important to the aroma of the commercial essence than that of the fresh fruit.

Chen *et al.* (2007) identified the volatile compounds of *Psidium guajava* L. (Taiwan) major constituents are α-pinene, 1,8-cineole, β-caryophyllene, nerolidol, globulol, C6 aldehydes, C6 alcohols, ethyl hexanoate and (Z) 3-hexenyl acetate. The presence of C6 aldehydes, C6 alcohols, ethyl hexanoate, (Z)-3-hexenyl acetate, terpenes and 1,8-cineole is thought to contribute to the unique flavor of the guava fruits. Steinhaus *et al.* (2008) studied volatiles present in fresh, pink-fleshed Colombian guavas (*Psidium guajava* L.), variety *regional rojo*, were carefully isolated by solvent extraction followed by solvent-assisted flavor evaporation and the aroma-active areas in the gas chromatogram were screened by application of the aroma extract dilution analysis. This study revealed that the identification experiments in combination with the FD factors revealed 4-methoxy-2,5-dimethyl-3(2*H*)-furanone, 4-hydroxy-2,5-dimethyl-3(2*H*)-furanone, 3-sulfanylhexyl acetate and 3-sulfanyl-1-hexanol followed by 3-hydroxy-4,5-dimethyl-2(5*H*)-furanone, (*Z*)-3-hexenal, *trans*-4,5-epoxy-(*E*)-2-decenal, cinnamyl alcohol, ethyl butanoate, hexanal, methional and cinnamyl acetate as important aroma contributors. Enantioselective gas chromatography revealed an enantiomeric distribution close to the racemate in 3-sulfanylhexyl acetate as well as in 3-sulfanyl-1-hexanol. In addition, two fruity smelling diastereomeric methyl 2-hydroxy-3-methylpentanoates were identified as the (*R,S*)- and the (*S,S*)-isomers, whereas the (*S,R*)- and (*R,R*)-isomers were absent. Seven odorants were identified for the first time in guavas, among them 3-sulfanylhexyl acetate, 3-sulfanyl-1-hexanol, 3-hydroxy-4,5-dimethyl-2(5*H*)-furanone, *trans*-4,5-epoxy-(*E*)-2-decenal and methional were the most odor-active.

The leaves: The constituents of essential oils from the leaves of Guava were analysed by GC-MS qualitatively and quantitatively. The leaves contain fixed oil and volatile oil. The leaves of *P. guajava* contain an essential oil rich in cineol, tannins, triterpenes, flavanoids, resin, tannin, eugenol, mallic acid, fat, cellulose, chlorophyll, mineral salts and a number of other fixed substances (Olajide *et al.*, 1999; Burkill, 1997; Nadkarni and Nadkarni, 1999). The essential oil with the main components being α-pinene, β-pinene, limonene, menthol, terpenyl acetate, isopropyl alcohol, longicyclene, The major volatiles β-caryophyllene, (*E*)-nerolidol (Ogunwande *et al.*, 2003), β-bisabolene, caryophyllene oxide, β-copanene, farnesene, humulene, selinene, cardinene, curcumene (Zhang *et al.*, 1994), α-Selinene, capaene, [1aR-(1a α-, 4a α-, 7 α-, 7a β-, 7b α-)]-decahydro-1,1,7-trimethyl-4-methylene-1H-cycloprop[e] azulene, eucalyptol (Li *et al.*, 1999), α-caryophyllene and δ-selinene (Sagrero-Nieves *et al.*, 1994). Leaf oil samples prepared from solvent extracts found menthol and R-terpenyl acetate along with ethanol and propanol (Osman *et al.*, 1975). Early leaf volatile studies examined terpene concentrations in leaf essential oils for chemotaxonomy purposes (Smith and Siwatibau, 1975). The volatile fraction was rich in sesquiterpene compounds. Fifty-seven components including 27 terpenes (or sesquiterpenes) along with 14 alcohols and 4 esters were identified obtained from a hydrodistillation of the leaves (Pino *et al.*, 2001a) and forty-two constituents including 29 hydrocarbon terpenes were observed in the air-dried and steam-distilled guava leaf oil from Nigeria (Ogunwande *et al.*, 2003). Chief among the terpenes were limonene, β-caryophyllene. γ-bisabolene and zingiberene nerolidiol, β-sitosterol, ursolic, crategolic, guayavolic acids, guajavolide and guavenoic acid along with one known triterpene oleanolic acid were isolated from the leaves of *Psidium guajava* L. (Pino *et al.*, 2001a; Iwu, 1993; Begum *et al.*, 2002). Recent reports are confirmed the presence of β-caryophyllene, α-pinene and 1,8-cineole as major compounds in Guava leaf essential oil (Chen and Yen, 2007; Ogunwande *et al.*, 2003). In addition, the essential oil rich in cineol and four triterpenic acids as well as three flavonoids; quercetin, its 3-L-4-4-arabinofuranoside (avicularin) and its 3-L-4-pyranoside with strong antibacterial action (Bep, 1986). We are identified flavanone-2 2-ene, prenol, dihydro benzophenanrhridine and cryptonine. These four new compounds are first identified from guava leaf essential oil (Joseph and Priya, 2010). Recent report identified new sulfur volatile compounds namely, dimethyl disulfide, dimethyl trisulfide, benzothiazole, 3-mercaptohexanol and 3-mercaptohexyl acetate. Two of these compounds have not previously been reported as occurring in guava (3-mercapto-hexanol and 3-mercaptohexyl acetate). These compounds have a cassis-like odor and are thought to make an important contribution to the odor of guava (Clery and Hammond, 1998).

Pharmaceutical effect of Guava essential oil

Antimicrobial activity: The mechanisms by which essential oils can inhibit microorganisms involve different modes of action and in part may be due to their hydrophobicity. As a result, they get partitioned into the lipid bilayer of the cell membrane, rendering it more permeable, leading to leakage of vital cell contents (Burt, 2004; Juven *et al.*, 1994). Some antimicrobial screening has been done selectively by different researcher in Guava essential oil. Sacchetti *et al.* (2005) reported the *Psidium guajava* L. oil showed strong resistance against *Yarrowia lipolytica* (pathogenic yeast). The antimicrobial effect of essential oil from guava leaves tested against strains of *Staphylococcus aureus*, *Salmonella* and *Escherichia coli* isolated from seabob shrimp [(*Xiphopenaeus kroyeri* (Heller)]. The essential oil extract showed inhibitory activity against *S. aureus* and *Salmonella* sps. (Goncalves *et al.*, 2008; Joseph *et al.*, 2010), a higher concentration of active chemical compounds in essential oils explain their stronger inhibitory action (Jaiarj *et al.*, 1999; Neto *et al.*, 1994). Recently, we are reported the essential oil from the leaves of guava exhibited inhibitory effect against *Bacillus cereus, Enterobactor aerogenes* and *Pseudomonas fluorescens* (Joseph *et al.*, 2010). Within the genus *Psidium,* essential oil constituents are principally comprised of monoterpenes, 1.8-cineol, ρ-cimen and acetate of α-terpenil. The complex composition of essential oils offers a variety of pharmacological resources and great potential for the development of novel drugs.

Antinociceptive effect: Santos *et al.* (1998) reported that the *Psidium guajava* leaf essential oil and its major constituents, β-caryophyllene and α-pinene having antinocieptive effect on adult male albino mice. It was assessed by using chemical (formalin and acetic acid) and thermal (hot-plate) nociceptive tests. The possible mechanisms involved in the antinociceptive effect of the essential oil, animals received caffeine or naloxone 15 min before oral administration of this essential oil.

Insecticidal activity: Essential oils are also reported to have insecticide properties, essentially as ovicidal, larvicidal, growth inhibitor, repellency and antifeedant (Saxena and Koul, 1978; Dale and Saradamma, 1981; Schearer, 1984; Krishnarajah *et al.*, 1985; Nath *et al.*, 1986; Koul, 1987; Isman *et al.*, 1990; Shaaya *et al.*, 1991; Lahlou *et al.*, 2001a, b). Recently identified the potential component(s) responsible for guava's protective effect against the Asian citrus psyllid (*Diaphorina citri* Kuwayama), which is the insect vector of Huanglongbing (HLB) or citrus greening disease. Seven sulfur volatiles were detected Volatiles from crushed and intact guava leaves (*Psidium guajava* L.). Among these 7 compounds, DMDS (dimethyl disulfide) is an insect toxic; defensive volatile produced only by wounded guava. It is the major component it may responsible for the protective effect of guava against the HLB vector (Rouseff *et al.*, 2008).

Repellent activity: Nowadays, the use of plant essential oils in mosquito repellent is an alternative personal protective measure against the noxious effects of synthetic repellents on the users and environment (Thorsell *et al.*, 1998). Rajkumar and Jebanesan (2007) reported repellent activity against malarial fever mosquito *Anopheles stephensi* using the human-bait technique. *P. guajava* showed repellency. Another report proved that the essential oil of guava showed excellent repellency against *B. germanica* cockroaches and moderate activity showed *N. rhombifolia* cockroaches (Thavara *et al.*, 2007). This essential oil did not cause skin irritation, hot sensations or rashes on the arms of the test volunteers during the study period (Rajkumar and Jebanesan, 2007).

Anticancer activity: Many essential oil components have been screened in the search for anticancer agents. Essential oils and their individual aroma components showed cancer suppressive activity when tested on number of human cancer cell lines including glioma, colon cancer, gastric cancer, human liver tumor, pulmonary tumors, breast cancer, leukemia and others (Angelis, 2001). In a recent study, essential oil from the leaves of the plant was reported to exhibit anticancer activities on KB and P388 cell lines. It was reported that essential oil from the leaves of *P. guajava* exhibited the highest antiproliferative activity towards KB cells compared to sixteen other Thai medicinal plants screened (Manosroi *et al.*, 2005). Recently, we reported the potential cytotoxic effect on human cervical cancer cell lines and it may have probable apoptosis (Joseph *et al.*, 2010).

Anti-inflammatory effect: Olajide *et al.* (1999) reported that the anti-inflammatory effects of methanol extract from leaves were probably due to the essential oils present in the guava plant. According to this result, the flavonoid content on the plant could also be responsible for the anti-inflammatory activity.

Future prospectus: The cytotoxic capacity of the essential oils based on a pro-oxidant activity can make them excellent antiseptic and antimicrobial agents for personal use, i.e., for purifying air, personal hygiene, or even internal use via oral consumption and for insecticidal use for the preservation of crops or food stocks. Recent studies have demonstrated that the pro-oxidant activity of some essential oils or some of their constituents, as also that of some polyphenols is very efficient in reducing local tumor volume or tumor cell proliferation by apoptotic and/or necrotic effects. We have shown that the guava leaf essential oil has a cytotoxic activity on the human cervical cancer cell lines (Joseph *et al.*, 2010). (Manosroi *et al.* (2005) have shown anticancer activities on KB and P388 cell lines. Many tumor cells are characterized by severe changes in energy metabolism, mitochondrial overproduction and permanent oxidative stress (Czarnecka *et al.,* 2006). Essential oils, due to their capacity to interfere with mitochondrial functions, may add pro-oxidant effects and thus become genuine antitumor agents. Many radical producing agents are in fact used in antitumor treatments. In the case of essential oils, radical production could be very well controlled and targeted without presenting by it any toxic or mutagenic side-effects to healthy tissues. Essential oils or their active constituents could be included in vectorized liposomes that would allow bettering defining the quantities applied. Thus, the *Psidium guajava* L. essential oil could make their way into the modern medical domain.

CONCLUSION

This study attempts to shed light on the therapeutic potential of *Psidium guajava* L. essential oil and their aroma volatile constituents in the prevention or therapy of disease. From this study we can concluded that the preliminary studies only reported from essential oil of *Psidium guajava* L. (Guava). The results reviewed in this study are aimed at attracting the attention of researchers seeking new drugs from guava essential oil and its chemical compounds. The data presented provide basic information's about guava plant, essential oil, chemical constituents and its pharmacological effects described here. This essential oil and their constituents can hopefully be considered in the future for more clinical evaluations and possible applications and as adjuvant to current medications. We should maintain our efforts in considering and valorizing our natural patrimony, as well as conducting more scientific research on *Psidium guajava* L. from chemical analysis, biological, toxicological and pharmacological investigations to therapeutic aspects.

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REFERENCES

Abdelrahim, S.I., A.Z. Almagboul, M.E. Omer and A. Elegami, 2002. Antimicrobial activity of *Psidium guajava* L. Fitoterapia, 73: 713-715.

Amella, M., C. Bronner, F. Briancon, M. Haag, R. Anton and Y. Landry, 1985. Inhibition of mast cell histamine release by flavonoids and bioflavonoids. Planta. Med., 51: 16-20.

Angelis, L.D., 2001. Brain tumors. N. Engl. J. Med., 344: 114-123.

Begum, S., S.I. Hassan and B.S. Siddiqui, 2002. Two new triterpenoids from the fresh leaves of *Psidium guajava*. Planta Med., 68: 1149-1152.

Begum, S., S.I. Hassan, S.N. Ali and B.S. Siddiqui, 2004. Chemical constituents from the leaves of Psidium guajava. Nat. Prod. Res., 18: 135-140.

Bep, O.B., 1986. Medicinal Plants in Tropical West Africa. Cambridge University Press, Cambridge, ISBN: 0-521-26815-X.

Buchbauer, G., W. Jager, L. Jirovetz, J. Imberger and H. Dietrich, 1993. Therapeutic Properties of Essential Oils and Fragrances. In: Bioactive Volatile Compounds from Plants, Teranishi, R., R. Buttery and H. Sugisawa (Eds.). American Chemical Society, Washington, DC., pp: 161.

Buchbauer, G., 2000. The detailed analysis of essential oils leads to the understanding of their properties. Perfumer Flavorist, 25: 64-67.

Burkill, H.M., 1997. The Useful Plants of West Tropical Africa. 2 Edn., Royal Botanical Gardens, Kew, London.

Burt, S.A., 2004. Essential oils: Their antibacterial properties and potential applications in foods: A review. Int. J. Food Microbiol., 94: 223-253.

Busse, W.W., D.E. Kopp and E. Middleton, 1984. Flavonoid modulation of human neutrophil function. J. Allergy Clin. Immunol., 73: 801-809.

Chen, H.C., M.J. Sheu and C.M. Wu, 2006. Characterization of volatiles in guava (*Psidium guajava* L. cv. Chung-Shan-Yueh-Pa) fruit from Taiwan. J. Food Drug Anal., 14: 398-402.

Chen, H.C., M.J. Sheu, L.Y. Lin and C.M. Wu, 2007. Chemical composition of the leaf essential oil of *Psidium guajava* L. from Taiwan. J. Essent. Oil Res., 19: 345-347.

Chen, H.Y. and G.C. Yen, 2007. Antioxidant activity and free radical-scavenging capacity of extracts from guava (*Psidium guajava* L.) leaves. Food Chem., 101: 686-694.

Chyau, C.C. and C.M. Wu, 1989. Differences in volatile constituents between inner and outer flesh-peel of guava (*Psidium guajava*, L.) fruit. Lebensm. Wiss. Technol., 22: 104-106.

Chyau, C.C., S.Y. Chen and C.M. Wu, 1992. Differences of volatile and nonvolatile constituents between mature and ripe guava (*Psidium guajava* L.) fruits. J. Agric. Food Chem., 40: 846-849.

Clery, R.A. and C.J. Hammond, 1998. New sulfur components of pink guava fruit (*Psidium guajava* L.). J. Essent. Oil Res., 20: 315-317.

Czarnecka, A.M., P. Golik and E. Bartnik, 2006. Mitochondrial DNA mutations in human neoplasia. J. Appl. Genet., 47: 67-78.

Dale, D. and K. Saradamma, 1981. Insect antifeedant action of some essential oils. Pesticides, 15: 21-22.

Ekundayo, O., F. Ajani, T. Seppaenen-Laakso and I. Laakso, 1991. Volatile constituents of *Psidium guajava* L. (guava) fruit. Flavour. Fragance J., 6: 233-236.

Farkas, L., M. Gabor, F. Kallay and H.I. Wagner, 1982. Flavonoids and Bioflavonoids. Elsevier, New York, pp: 443-50.

Goncalves, F.A., M.A. Neto, J.N.S. Bezerra, A. Macrae, O.V.D. Sousa, A.A. Fonteles-Filho and R.H.S.F. Vieira, 2008. Antibacterial activity of guava, *Psidium guajava* Linnaeus, leaf extracts on diarrhea-causing enteric bacteria isolated from seabob shrimp, *Xiphopenaeus kroyeri* (Heller). Rev. Inst. Med.Trop. S. Paulo., 50: 11-15.

Guttner, J., A. Veckenstedt, H. Heinecke and R. Pusztai, 1982. Effect of quercetin on the course of mengo virus infection in immunodeficient and normal mice: A histological study. Acta. Virol., 26: 148-155.

Hashinaga, F., Y. Shima and S. Itoo, 1987. Production of volatile components of guava during maturation. Bull. Fac. Agric. Kagoshima Univ., 37: 59-64.

Havsteen, B., 1983. Flavonoids, a class of natural products of high pharmacological potency. Biochem. Pharmacol., 32: 1141-1148.

Idstein, H. and P. Schreier, 1985. Volatile constituents from guava (*Psidium guajava* L.) fruit. J. Agric. Food Chem., 33: 138-143.

Isman, M.B., O. Koul, A. Luezynski and J. Kaminiski, 1990. Insecticidal and antifeedant bioactivities of neem oil and their relationship to azadirachtin content. J. Agric. Food Chem., 38: 1406-1411.

Iwu, M.M., 1993. Handbook of African Medicinal Plants. 1st Edn., CRC Press, Boca Raton, FL., ISBN-10: 084934266X.

Jaiarj, P., P. Khoohaswan, Y. Wongkrajang, P. Peungvicha, P. Suriyawong, M.L. Saraya and O. Ruangsomboom, 1999. Anticough and antimicrobial activities of *Psidium guajava* leaves extract. J. Ethopharmacol., 67: 203-212.

Jordan, M.J., C.A. Margaria, P.E. Shaw and K.I. Goodner, 2003. Volatile components and aroma active compounds in aqueous essence and fresh pink guava fruit puree (*Psidium guajava* L.) by GC-MS and multidimensional GC/GC-O. J. Agric. Food Chem., 51: 1421-1426.

Joseph, B. and R.M. Priya, 2010. *In vitro* Antimicrobial activity of *Psidium guajava* L. leaf essential oil and extracts using agar well diffusion method. Int. J. Curr. Pharmaceutical Res., 2: 28-32.

Joseph, B., R.M. Priya P.A.M. Helen and S. Sujatha, 2010. Bio-active compounds in essential oil and its effects of antimicrobial, cytotoxic activity from the *Psidium guajava* (L.) Leaf. J. Adv. Biotechnol., 9: 10-14.

Juven, B.J., J. Kanner, F. Schved and H. Weisslowicz, 1994. Factors that interact with the antibacterial action of thyme essential oil and its active constituents. J. Applied Bacteriol., 76: 626-631.

Kaneuchi, M., M. Sasaki, Y. Tanaka, N. Sakuragi, S. Fujimoto and R. Dahiya, 2003. Quercetin regulates growth of Ishikawa cells through the suppression of EGF and cyclin D1. Int. J. Oncol., 22: 159-164.

Karawya, M.S., S.M.A. Wahab, M.S. Hifnawy, S.M. Azzam and H.M.E. Gohary, 1999. Essential oil of egyptian guajava leaves. Egypt J. Biomed. Sci., 40: 209-216.

Kaul, T.N., M.D.E. Middleton and P.L. Ogra, 1985. Antiviral effects of flavonoids on human viruses. J. Med. Virol., 15: 71-79.

Koul, O., 1987. Antifeedant and growth inhibitory effects of calamus oils and neem oil on *Spodoptera* litura under laboratory conditions. Phytoparasitica, 15: 169-180.

Krishnarajah, S.R., V.K. Ganesalingam and U.M. Senanayake, 1985. Repellancy and toxicity of some plant oils and their terpene components to *Sitotraga cerealilla* (Olivier, Lepidoptera, Gelechiidae). Trop. Sci., 25: 249-252.

Lahlou, M. and R. Berrada, 2003. Composition and niticidal activity of essential oils of three chemotypes of *Rosmarinus officinalis* L. acclimatised in Morocco. Flav. Frag. J., 18: 124-127.

Lahlou, M., R. Berrada and M. Hmamouchi, 2001a. Molluscicidal activity of thirty essential oils on *Bulinus truncatus*. Therapie, 56: 71-72.

Lahlou, M., R. Berrada, M. Hmamouchi and M. Lyagoubi, 2001b. Effect of some Moroccan medicinal plants on mosquito larvae. Therapie, 56: 193-196.

Li, J., F. Chen and J. Luo, 1999. Gc-MS analysis of essential oil from the leaves of *Psidium guajava*. Zhong Yao Cai, 22: 78-80.

Lutterodt, G.D., 1989. Inhibition of microlaxinduced experimental diarrhoea disease with narcotic-like extract of *Psidium guajava* L. leaf. J. Ethnopharmacol., 25: 235-235.

MacLeod, A.J. and N.G. Troconis, 1982. Volatile flavor components of guava. Phytochemistry, 21: 1339-1342.

Manosroi, J., P. Dhumtanom and A. Manosroi, 2005. Anti-proliferative activity of essential oil extracted from Thai medicinal plants on KB and P388 cell lines. Cancer Lett., 235: 114-120.

Middleton, E. and G. Drzewieki, 1984. Flavonoid inhibition of human basophil histamine release stimulated by various agents. Biochem. Pharmacol., 33: 3333-3338.

Middleton, E. and G. Drzewieki, 1985. Naturalty occurring flavonoids and human basophil histamine release. Int. Arch. Allergy Appl. Immunol., 77: 155-157.

Morales, M.A., J. Tortoriello, M. Meckes, D. Paz and X. Lozoya, 1994. Calcium-antagonist effect of quercetin and its relation with the spasmolytic properties of *Psidium guajava* L. Arch. Med. Res., 25: 17-21.

Motooka, P., L. Castro, D. Nelson, G. Nagai and L. Ching, 2003. Weeds of Hawaii's Pastures and Natural Areas: An Identification and Management Guide. College of Tropical Agriculture and Human Resources, University of Hawaii, Honolulu, HI.

Mucsi, I. and B.M. Pragai, 1985. Inhibition of virus multiplication and alteration of cyclic AMP level in cell cultures by flavonoids. Experientia, 41: 930-931.

Muhammad, Z. and A.M. Mustafa, 1994. Traditional Malay Medicinal Plants. Fajar Bakti Sdn. Bhd., Kuala Lumpur, ISBN: 967-65-2476-X.

Murray, M.T. and J.E. Pizzorno, 1999. Flavonoids-Quercetin, Citrus Favonoids and HERs (Hydroxylethylrutosides). In: Text Book of Natural Medicine, Pizzorno, J.E. and M.E. Murray (Eds.). Harcourt Brace and Co. Ltd., London, pp: 745-750.

Nadkarni, K.M. and A.K. Nadkarni, 1999. Indian Materia Medica-with Ayurvedic, Unani-Tibbi, Siddha, Allopathic, Homeopathic, Naturopathic and Home remedies. Popular Prakashan Private Ltd., Bombay, India, ISBN: 81-7154-142-9.

Nair, R. and S. Chanda, 2007. *In vitro* antimicrobial activity of *Psidium guajava* L. leaf extracts against clinically important pathogenic microbial strains. Braz. J. Microbiol., 38: 452-458.

Nakamura, Y., S. Ishimitsu and Y. Tonogai, 2000. Effects of quercetin and rutin on serum and hepatic lipid concentrations, fecal steroid excretion and serum antioxidant properties. J. Health Sci., 46: 229-240.

Nath, D.R., N.G. Das and P.R. Malhotra, 1986. Efficacy of certain essential oils as insects repellents. Def. Sci. J., 36: 327-327.

Neto, M.A., J.W.D. Alencar, E.R. Silveira, A.N. Cunha and T.G. Batista, 1994. Volatile constituents of *Psidium pohlianum* Berg and *Psidium guyanensis* Pers. J. Essential Oils Res., 6: 299-300.

Nishimura, O., K. Yamaguchi, S. Mihara and T. Shibamoto, 1989. Volatile constituents of guava fruit (*Psidium guajava* L.) and canned puree. J. Agric. Food Chem., 37: 139-142.

Ogunwande, I.A., N.O. Olawore, K.A. Adeleke, O. Ekundayo and W.A. Koenig. 2003. Chemical composition of the leaf volatile oil of *Psidium guajava* L. growing in Nigeria. Flavour Fragrance J., 18: 136-138.

Ojewole, J.A.O., 2006. Anti-Inflammatory and analgesic effects of *Psidium guajava* L. (Myrtaceae) leaf aqueous extracts in rats and mice. Methods Find. Exp. Clin. Pharmacol., 28: 441-446.

Olajide, O.A., S.O. Awe and J.M. Makinde, 1999. Pharmacological studies on the leaf of *Psidium guajava*. Fitoterapia, 70: 25-31.

Osman, A.M., M.E.G. Younes and A.E. Sheta, 1975. Chemical examination of local plants. Part VII. *Psidium guajava* L. leaf extracts. Egypt. J. Chem., 18: 347-352.

Paniandy, J.C., J. Chane-Ming and J.C. Pieribattesti, 2000. Chemical composition of the essential oil and headspace solid-phase micro-extraction of the guava fruit (*Psidium guajava* L.). J. Essent. Oil Res., 12: 153-158.

Pearce, F., A.D. Befus and J. Bienenstock, 1984. Mucosal mast cells: III Etfect of quercetin and other flavonoids on antigen-induced histamine secretion from rat intestinal mast cells. J. Allergy Clin. Immunol., 73: 819-823.

Pino, J.A., J. Aguero, R. Marbot and V. Fuentes, 2001a. Leaf oil of *Psidium guajava* L. from Cuba. J. Essent. Oil Res., 13: 61-62.

Pino, J.A., R. Marbot and C. Vazquez, 2001b. Characterization of volatiles in strawberry guava (*Psidium cattleianum* Sabine) fruit. J. Agric. Food Chem., 49: 5883-5887.

Pino, J.A., R. Marbot and C. Vazquez, 2002. Characterization of volatiles in Costa Rican guava [*Psidium friedrichsthalianum* (Berg) Niedenzu] fruit. J. Agric. Food Chem., 50: 6023-6026.

Rajkumar, S. and A. Jebanesan, 2007. Repellent activity of selected plant essential oils against the malarial fever mosquito *Anopheles stephens*. J. Trop. Biomed., 24: 71-75.

Rouseff, R.L., E.O. Onagbola, J.M. Smoot and L.L. Stelinski, 2008. Sulfur volatiles in guava (*Psidium guajava* L.) leaves: Possible defense mechanism. J. Agric. Food Chem., 56: 8905-8910.

Roy, C.K., J.V. Kamath and M. Asad, 2006. Hepatoprotective activity of *Psidium guajava* Linn. leaf extract. Ind. J. Exp. Biol., 44: 305-311.

Sacchetti, G., S. Maietti, M. Muzzoli, M. Scaglianti, S. Manfredini, M. Radice and R. Bruni, 2005. Comparative evaluation of 11 essential oils of different origin as functional antioxidants, antiradicals and antimicrobials in food. Food Chem., 91: 621-632.

Sagrero-Nieves, L., J.P. Bartley and A. Provis-Schwede, 1994. Supercritical fluid extraction of the volatile components from the leaves of *Psidium guajava* L. (guava). Flavour Fragrance J., 9: 135-137.

Santos, F.A., V.S.N. Rao and E.R. Silveira, 1998. Investigations on the antinociceptive effect of *Psidium guajava* leaf essential oil and its major constituents. Phytother. Res., 12: 24-27.

Saxena, B.P. and O. Koul, 1978. Utilisation of essential oils for insect control. Indian Perfum., 22: 139-149.

Schearer, W.R., 1984. Components of oil of tansy (*Tanacetum vulgare*) that repel colorado potato beetles (*Leptinotarsa decemlineata*). J. Nat. Prod., 47: 964-969.

Shaaya, E., U. Ravid, N. Paster, B. Juven, U. Zisman and V. Pissarev, 1991. Fumigant toxicity of essential oils against four major stored-product insects. J. Chem. Ecol., 17: 499-504.

Smith, R.M. and S. Siwatibau, 1975. Sesquiterpene hydrocarbons of fijian guavas. Phytochemistry, 14: 2013-2015.

Steinhaus, M., D. Sinuco, J. Polster, C. Osorio and P. Schieberle, 2008. Characterization of the Aroma-active compounds in pink guava (*Psidium guajava* L.) by application of the aroma extract dilution analysis. J. Agric. Food Chem., 56: 4120-4127.

Stevens, K.L., J.E. Brekke and D.J. Stern, 1970. Volatile constituents in guava. J. Agric. Food Chem., 49: 598-599.

Sunagawa, M., S. Shimada, Z. Zhang, A. Oonishi, M. Nakamura and T. Kosugi, 2004. Plasma Insulin concentration was increased by long-term ingestion of guava juice in spontaneous non-insulin-dependant diabetes mellitus (NIDDM) rats. J. Health. Sci., 50: 674-678.

Tanaka, T., N. Ishida, M. Ishimatsu, G. Nonaka and I. Nishioka, 1992. Six new complex tannins, guajavins, psidins and psiguavin from the bark of *Psidium guajava* L. Chem. Pharm. Bull., 40: 2092-2098.

Tangpu, T.V. and A.K. Yadav, 2006. Anticestodal efficacy of *Psidium guajava* against experimental *Hymenolepis diminuta* infection in rats. Indian J. Pharmacol., 38: 29-32.

Thavara, U., A. Tawatsin, P. Bhakdeenuan, P. Wongsinkongman and T. Boonruad *et al.*, 2007. Repellent activity of essential oils against cockroaches (Dictyoptera: Blattidae, Blattellidae and Blaberidae) in Thailand. Southeast Asian J. Trop. Med. Public Health., 38: 663-673.

Thorsell, W., A. Mikiver, I. Malander and H. Tunon, 1998. Efficacy of plant extracts and oils as mosquito repellents. Phytomedicine, 5: 311-323.

Vernin, G., E. Vernin, C. Vernin and J. Metzger, 1991. Extraction and gc-ms-specma data bank analysis of the aroma of *Psidium guajava* L. fruit from Egypt. Fragance. J., 6: 143-148.

Wilson, C.W. and P.E. Shaw, 1978. Terpene hydrocarbons from *Psidium guajava*. Phytochemistry, 17: 1435-1436.

Yen, G.C. and H.T. Lin, 1999. Changes in volatile flavor components of guava juice with high-pressure treatment and heat processing and during storage. J. Agric. Food Chem., 47: 2082-2087.

Yen, G.C., H.T. Lin and P. Yang, 1992. Changes in volatile flavor components of guava puree during processing and frozen storage. J. Food Sci., 57: 679-681.

Yoshimoto, T., M. Furukawa, S. Yamamoto, T. Horie and S. Watanabe-Kohno, 1983. Flavonoids potent inhibitors of arachidonate 5-lipoxygenase. Biochem. Biophys. Res. Commun., 116: 612-618.

Zhang, W., B. Chen, C. Wang, Q. Zhu and Z. Mo, 2003. Mechanism of quercetin as antidiarrheal agent. Di Yi Jun Yi Da Xue Xue Bao., 23: 1029-1031.