ISSN:0975-1459
Journal of Pharmaceutical Sciences and Research
www.jpsr.pharmainfo.in

A Review on Antimicrobial Activity of *Psidium guajava* L. Leaves on Different Microbial Species, Antioxidant Activity Profile and Herbal Formulations

Rayjade Meghana S.[1*], Bhambar R. S.[1], Attarde Daksha L.[1]

[1]Department of Pharmacognosy, Mahatma Gandhi Vidyamabdir's Pharmacy College, Panchavati, Nashik-422003, Maharashtra, India.*

Abstract :

Psidium guajava Linn. Family- Myrtaceae (guava) is a short tree or shrub and folk medicinal plant. It is found in all over India. Each part of the guava tree is useful and has biological importance. Many phytochemicals are present in guava leaves such as flavanoids, alkaloids, tannins, saponins, glycosides, oil and fats, steroids, phenols, proteins, carbohydrates. It is used in various diseases like cough, diabetes, cardiac diseases, diarrhea, wound healing. Guava has various biological activities like antispasmodic, antimicrobial, hepato-protective, antioxidant, anti-diarrheal, anti-inflammatory, anti-allergy. Guava leaves contain quercetin in higher amount (2.15%), which gives antibacterial and antioxidant activity. Antioxidant activity of guava leaves is checked by various methods such as Oxygen Radical Absorbance Capacity using Flourescien (ORAC-FL), Hydroxyl Radicals, 2,2-diphenyl-1-picrylhydrazyl (DPPH), 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulphonic acid) (ABTS), Nitric Oxide Scavenging Activity, Nitrite Scavenging Activity, Reducing Power Assay. Guava leaves show better antimicrobial activity against fungal strain, gram positive, gram negative bacteria, yeast, moulds, bacteria isolated from urine samples, seabob shrimp and different microbial species such as *Escherichia coli, Salmonella enteritidis, Bacillus cereus, Staphyllococcus aureus, Saccharomyces cerevisiae, Aspergillus niger, Vibrio* and *Aeromonas* species, *Lactobacillus acidophilus, Acne vulgaris,* peridontal pathogens. Guava leaves are also reach in phenolic and flavanoid content.

Keywords : Antimicrobial activity, Antioxidant activity, *Psidium guajava* L.

INTRODUCTION :

Guava (*Psidium guajava* Linn. Family-Myrtaceae) is a tropical and subtropical tree or shrub. It is native to Mexico, America. Guava is known for different names in different regions, in English Guava; in Combodia Trabeksrok; in French Araca, Aracaiba; in Maharashtra Peru; in Gujrat Jamrud; in Assam Madhuriam; in Deccan Guava or Jam or Laljam or Safedjam. Height of the tree is up to 7 to 10 m high. Bark of the tree is smooth, pale pinkish brown or buff with grey patches. Stem is irregularly fluted when old. Leaves are opposite, about 10-15 cm long, elliptic or oblong in shape. Flowers are white in color, 2.5-3.8 cm in diameter. Fruit is globose or pyriform berry 5 cm length or more. Stem, bark, roots and leaves are astringent. Fruit is laxative (1),(2).

It contains various phytochemicals in different extracts describe in Table 1 (12), (13), (15), (16). Concentration of phytochemicals shows in Table 2 (14). Fruit contains vitamin A, vitamin C, iron, phosphorus, calcium and minerals. Quercetin content is very high in guava which gives spasmolytic activity. It is also used in cough (3). It has many pharmacological or biological activities such as antimicrobial, anti-diarrheal, anti-inflammatory, anti-allergic, hepato-protective, anti-diabetic, antispasmodic, sedative, hypertension, obesity, antioxidant etc. It has better activity against ulceration (4).

Chemical composition of guava leaves

Guava leaves contains tannins and polyphenols in high amount. Pedunculagin, castalagin, casuarinin and stenophyllanin A, these are the polyphenols present in the guava leaves which exhibit the anti-bacterial activity. Penta-o-galloyl-β-D-glucose (PGG), (-)-epigallocatechin gallate (EGCG) and alkyl gallate such as isoamyl galate (IG) and n-octyl gallate, these are tannins and polyphenols -present in guava leaves (13). It contains resin, sugars, triterpenes, ellagitannibs, flavan-3-ols, proanthocynidins (5). Guava leaves contains high amount of essential oil. It is the rich source of β-caryophyllene. It contains 20.34% of β-caryophyllene (6). Hyperoside, isoquercitrin, reynoutrin, guajaverin, avicularin, 2,4,6-trihydroxy-3,5-dimethylbenzophenone 4-O-(6"-O-galloyl)-β-d-glucopyranoside present in Chinese guava leaves (7). Guava leaves contains high amount of quercetin that is 2.15% which gives antibacterial activity. It also contains kaemferol that is 0.02% (8). Quercetin content is 0.18-0.393 % quantified by HPTLC-UV (9). Two flavanoid glycosides i.e morin-3-O-α-L-lyxopyranoside & morin-3-O-α-L-arabopyranoside and flavanoid (guajavarin)are present in guava leaves (10). It contains pentacyclic triterpenoids such as guajanoic acid, saponin, carotenoids, lectins, leucocyanidin, ellagic acid, amritoside, β-sitosterol, uvaol, oleanolic acid & ursolic acid (11).

Anti-microbial activity of guava leaves

Bipul Biswas et al. studied the antimicrobial activity of guava leaf extract against *Escherichia coli, Salmonella enteritidis* (gram –ve bacteria) and *Bacillus cereus, Staphyllococcus aureus* (gram +ve bacteria) are used. Well diffusion method is used for the evaluation. Methanol and ethanol extract shows antibacterial activity against gram positive bacteria, Methanol extract shows 8.27 & 12.3 mm mean zone of inhibition and ethanol extract shows 6.11 & 11.0 mm mean zone of inhibition against *Bacillus cereus, Staphyllococcus aureus.* Methanol, ethanol, n-hexane and water extract does not show antibacterial activity against gram negative bacteria. Tannins are polyphenolic compounds, which inhibit the protein

synthesis by binding with the prolin rich protein. Flavanoids are produced by plants these are hydroxylated polyphenolic compounds which shows antimicrobial activity in-vitro. They bind extracellular, soluble protein and bacterial cell wall. Terpenoids shows anti-bacterial activity and used as aromatic substance. Saponin shows the anti-bacterial activity against the *Staphyllococcus aureus* i.e. gram positive bacteria (17).

Manika Das et al. studied the antifungal activity of guava leaves against *Saccharomyces cerevisiae* (yeast and fungal strain), *Aspergillus niger* (mould and fungal strain), *Bacillus subtilis*, (gram positive bacterial strain), *E. coli* (gram negative bacterial strain). Well diffusion method is used to estimate the zone of inhibition. Guava leaf extract shows more inhibitory action against gram positive bacterial strain i.e. *Bacillus subtilis* and fungal strain i.e. *Saccharomyces cereviceae* & *Aspegillus niger*. The zone of inhibition is 16 ± 4.3 mm, 18 ± 3.3mm & 19 ± 4.4 mm at 100 µL. It is less sensitive against gram negative bacteria i.e. *E. coli.* Guava leaf extract shows strong antimicrobial activity because it contains high amount phenols, flavanoids and tannins (18).

Fumi Yamanaka et al. studied the effect of polyphenols on *Vibrio* and *Aeromonas* species i.e. *Vibrio vulnificus, V. mimicus, V. parahaemolyticus* and *Aeromonas sobria.* Polyphenols are more resistant to the *V.vulnificus*. The MIC for *V. vulnificus* is 8-512 µg/mL. The MIC of *V. mimicus* and *V. parahaemolyticus* and *A. sobria* is 32-1024 µg/mL. *Vibrio* bacteria is more sensitive to n-octyl chains (medium length alkyl gallates). n-dodecyl gallate (long chain gallate) have the lower antibacterial effect, MIC is 64 µg/mL. MIC of Kanamycin (KM) reduces due to the isoamyl gallate (IG) against *V. mimicus*. Tetracycline is less effective against *V. parahaemolyticus* and with (-)-epigallocatechin gallate (EGCG). The antibacterial effect of TC is higher. Thus the polyphenols are effective against *Vibrio* species than the *Aeromonas* species (19).

Jean-De-Dieu Tamokou et al. studied the antibacterial activity of methanol extract of guava leaves, it is different as per bacterial species. Antibacterial activity depends on MBC (minimum bactericidal concentration) and MIC (minimum inhibitory concentration). For MIC & MBC determination broth micro dilution method is used. Lower MIC shows greater antibacterial activity whereas greater MIC shows lower antibacterial activity. *Bacillus subtilis*, *E. coli*, *Staphyllococcus aureus*, *Shigella flexneri* shows better antibacterial activity. The MIC value of these species is lower, so it shows better antibacterial activity. *Pseudomonas aeruginosa* does not show better antibacterial activity. The MIC value of this species is high, so it does not show better antibacterial activity. The MIC and MBC value of plant extract are higher than the reference drug amoxicillin. It means that the methanolic extract of guava leaves shows better antibacterial activity (20).

Priya Gurnani et al. reported that ethanolic extract of guava leaves shows better antibacterial activity against *Lactobacillus acidophilus*. Antibacterial activity is investigated by agar well diffusion method. The 20% ethanolic extract of guava leaves shows better antibacterial activity. 5%, 10%, 15% leaf extract also shows antibacterial activity i.e. 17.56mm, 16.14mm, 15.34mm but the zone of inhibition is less than 20% i.e. 21.34mm. Water extract of guava leaves also shows the antibacterial activity but less than ethanolic extract. DMSO does not show antibacterial activity. Chlorhexidine (CHX) is used as a standard & the concentration of CHX is 0.2% (22.25mm). The ethanolic extract of guava leaves shows better antibacterial activity and is effective against the *Lactobacillus acidophilus*. The difference between zone of inhibition of 20% ethanolic extract and CHX is 0.012 (21).

Y Sunaina Shetty et al. studied the antibacterial activity of aqueous and ethanolic extract of guava leaves against *Porphyromonas gingivalis* and *Aggregatibacter actinomycetemcomitance.* Well diffusion method is used to check the antibacterial activity.. *A. actinomycetemcomitance* is more susceptible to aqueous and ethanolic extract of guava leaves at lower concentration also i.e.18.2 ± 0.83mm at 50µL and 11.6 ± 0.54mm at 3.12µL. Whereas the *P. gingivalis* is not susceptible to lower concentration of aqueous and ethanolic extract i.e. 10.4 ± 0.54mm at 75µL and 15.4 ± 0.54mm at 75µL (22).

Muhammad Mushtaq et al. reported that methanol, acetone and N, N-dimethylformamide extract of guava leaves shows antimicrobial activity against gram negative bacteria and is checked by disc diffusion method . *Citrobacter* species and *Alcaligenes fecalis* are resistant to guava leaves extract. All the three extract active 73.6 % against *Pseudomonas* species, 93.75% against *E. coli*, 83.33% *Klebsiella* species and 66.66% against *Proteus* species. Fungal strains in which *Candida* species, *Cryptococcus* and *Trichosporum* species are susceptible to methanol, acetone and DMF extract of guava leaves and the percentage is methanol extract 37.5%, acetone extract 56.25%, DMF extract 31.25%. Aspergillus species are resistant to all the extract of guava leaves (23).

Elisa Friska Romasi et al. studied the antimicrobial effect of aqueous, hexane and ethyl acetate extract of guava leaves. It does not inhibit the effect of *Penicillium* species. Ethyl acetate extract can inhibit the effect of *Escherichia coli, Staphylococcus aureus,* and *Bacillus cereus* by agar diffusion method. Aqueous extract does not inhibit any microbial species. Hexane extract active against *Bacillus cereus* at 20-50% concentration. Hexane extract does not show antibacterial activity against *Escherichia coli, Staphylococcus aureus*. The zone of inhibition of ethyl acetate extract against *E.coli* is 9.34-10.06mm, against *S. aureus* is 7.99-12.95mm and against *B. cereus* is 6.17-7.51mm. The MIC and MBC of *E. coli* is 0.017% and 0.067%, *S. aureus* is 1.177% and 4.707%, *B. cereus* is 0.126% and 0.504%. Ethyl acetate extract inhibit the microbes at pH 4. As per the sugar concentration antibacterial activity is increases and the water activity also increases. The water activity is 0.978 at 10-30% 0.973 at 40%. Antibacterial activity of leaves extract is increase by the influence of salt and heating also (24).

Indriyani Nur et al. studied the antibacterial activity of guava leaf extract against *V. harveyi.* It shows inhibition at

5250 ppm dose. It can improve the physiological properties of white shrimp (*Litopenaeus vannamel*). Guava leaf extract is effective against vibriosis infection (25).

Manisha Pandey et al. studied the antibacterial activity of essential oil of guava leaves which are active against skin bacteria *Propionibacterium acnes* and *Staphylococcus epidermidis* which causes acne. Antibacterial activity tested by broth micro dilution method. MIC and IC_{50} value of *Propionibacterium acnes* is 0.321mg/ml and 0.309 mg/ml. MIC and IC_{50} value of *Staphylococcus epidermidis* is 0.486 mg/ml and 0.416 mg/ml. For comparative study Tetracyclin drug is used which shows MIC and IC_{50} value of *Propionibacterium acnes* is 0.028 mg/ml and 0.013 mg/ml. MIC and IC_{50} value of *Staphylococcus epidermidis* is 0.159 mg/ml and 0.106 mg/ml (26).

Flavia A.Goncalves et al. studied antimicrobial activity of essential oil and extract of guava leaves. *Staphylococcus aureus*, *Salmonella spp*., *E.coli* and *Xiehotenaeus kroyeri* (isolated from seabob shrimp) are use as a diarrhea causing bacteria. Antibacterial activity checked by disc diffusion method. Guava leaf extracts (methanol, hexane, ethyl acetate) are active against *Staphylococcus aureus.* Essential oil is effective against *Staphylococcus aureus*, *Salmonella spp*. Commercially available antibiotics are resisted in some amounts by the strains isolated from shrimp. Guava leaf extracts and essential oil are major sources of antimicrobial compounds (27).

Ekeleme Kenneth et al. studied the antimicrobial activity of guava leaf extracts against *Pseudomonas aeruginosa*, *E.coli*, *Staphylococcus aureus*, *Streptococcus pneumonie* and *Klebsiella pneumonie* isolated from urine sample. Antibacterial activity tested by cup-plate agar diffusion bioassay. The 25 mg concentration of ethanolic extract shows better inhibition i.e. *P. aeruginosa* 9.50 mm, *E.coli* 9.00 mm, *S. pneumonie* 10.50 mm, *K.pneumonie* 9.50 mm of zone of inhibition. 100 mg concentration of aqeous extract also shows better inhibition i.e. *E.coli* 12.50 mm *S. aureus* 14.50 mm *S. pneumonie* 9.00 mm of zone of inhibition (28).

Antioxidant activity of guava leaves

Jongkwon Seo et al. reported that the 50% hydroethanolic extract contains phenolic compound content in high amount than the ethanol, methanol and water extract. Higher the phenolic content, higher the antioxidant activity. 50% hydroethanolic content shows better antioxidant activity. Water and 50% hydroethanolic extract of guava leaves possess more DPPH- , ABTS scavenging activity and reducing power than pure ethanol, methanol, hexane and ethyl acetate extract of guava leaves. 50% hydroethanolic extract possess high nitric oxide and nitrite scavenging ability because it contains high phenolic content (29).

Julio Cesar Camarena-Tello et al. studied that Calvillo siglo XXI and Hidrozac varieties of guava leaf extracts have better antioxidant properties. Aqeous extract of Calvillo siglo XXI variety contains total phenolic content in high amount. Chloroform and acetone extract of Hidrozac variety contains total phenolic content in high amount. Acetone and chloroform extract of Calvillo siglo XXI variety contains total flavanoid content in high amount. Total phenolic content is positively related with Oxygen Radical Absorbance Capacity using Flourescein (ORAC-FL) and less positively related with hydroxyl radicals. Total flavanoid content is very less positively related with ORAC-FL and hydroxyl radicals (30).

K.Iamjud et al. reported that the ascorbic acid content, total phenolics and antioxidant activities of guava leaves extract. For total phenolics gallic acid is used as a standard i.e. 5304 ± 1485 mg per 100 gram on processing type of guava leaves extract. Ascorbic acid is present in local type of leaves in high amount i.e. 98 ± 21 mg per 100 gram. Green leaf contains 4584 ± 1710 mg per 100 gram phenolic content and 559 ± 242 µmol per gram antioxidant activity more than maroon leaf. Ascorbic acid is present in maroon leaf in high amount i.e. 142 ± 52 and 86 ± 29 mg per 100 gram (31).

Samir M. El-Amin et al. studied the total phenolic & total flavonoid contents, antioxidant and antimicrobial activities of guava leaves extracts. Gallic acid is used as a standard for phenolic extract, 324.26 in ethyl acetate extract and in methanol extract as per the concentration for 90%, 100%, 85% 397.25, 306.12, 216.21mg/g dry extract. Diethyl ether extract contains less quantity that is 55.13 mg/gm. For DPPH assay 8.0 positive ascorbic acid is used as a standard and the total antioxidant capacity is 436.02, 541.0, 412.13, 394.41, and 351.91mg/ g dry extract for n-butanol, 90% Methanol, Ethyl acetate 100% Methanol, 85% Methanol. Optical density of reducing power antioxidant activity is 0.873, 0.767, 0.712, 0.681, and 0.649 for n- butanol, 90% Methanol, Ethyl acetate 100% Methanol, 85% Methanol. For RPAA 0.970 of the positive ascorbic acid is used as a standard (32).

Chibuike Ibe et al. studied the antioxidant activities of guava and *Aloe vera*. In that total phenol, tannin, total flavanoid, total saponin, vitamin C, DPPH, free radical scavenging ability and TEAC are estimated. Antioxidant phytochemical content is more ($p<0.05$) in guava than the *Aloe vera*. Vitamin C is present in aloe vera more than guava. DPPH scavenging ability, TEAC is also higher in guava i.e. 0.056 mg/ml and 12.51 ± 0.40 mM/gdw (33).

Ravi Narayan Venkatachalam et al. studied the antioxidant activity of the methanolic extract of the *P. guajava* leaves. To study the antioxidant activity, reducing power, ferric reducing antioxidant power, linoleic acid assay, DPPH, nitric oxide, superoxide and hydrogen peroxide radical scavenging assays and phytochemical constituents i.e. flavanoids, phenol, tannin, chlorophyll and carotenoids also estimated. Phytochemicals are present in methanolic extract in high amount than the aqueous extract, antioxidant activity of methanolic extract is also greater than aqueous extract. Guava is a good nutraceutical that can be used to treat the diseases like diabetes (34).

Wei Cai Lee et al. reported that free radical (DPPH) scavenging assay, reducing power assay and also beta-carotene bleaching assay are measured to evaluate the antioxidant efficacy of guava leaves essential oil. Butylated hydroxytoulene (BHT) and ascorbic acid are used as a standard to check antioxidant efficacy. Guava leaves essential oil shows a concentration-dependent free

radical scavenging activity and inhibit DPPH radicals as a moderate antioxidant. IC_{50} value is 460.37 ± 1.33µg/mL. It inhibit the oxidation of β-carotene with 1% and the value of β-carotene bleaching assay is 81.67 ±1.48%. It also contains phenolic content which assess by Folin-Ciocalteu's phenol method and gallic acid is used as standard. The content found to be 495.93 ± 7.88 mg of GAE/g. The essential oil of guava leaves is a average source of natural antioxidants (35).

Deepa Phillip C et al. studied the evaluation of phytochemicals, antioxidant and anti microbial activity of white and pink guava. The leaf extracts phenols, glycosides, flavonoids and steroids. Antioxidant activity is estimated by FRP (Ferric reducing power assay) method. This method shows better antioxidant activity in aqueous and ethanol extract. Disc diffusion method is used for antibacterial activity. *Pseudomonas aeruginosa*, and *Klebsiella pneumonia* shows maximum zone of inhibition. *P. guajava* fruit extract does not show antibacterial activity against *Escherchia coli*. It means that guava leaves extract shows better antioxidant activity, antibacterial activity and phytochemicals than fruit extract (36).

Subba Rao Ch. et al. studied the in vitro antioxidant activity of the leaves and bark of guava. Ethanolic extract is used for the study. Nitric oxide and DPPH are used for free radical scavenging activity. IC_{50} of leaves extract is 630 µg/ml, bark extract is 590µg/ml. Vitamin C is used as a standard and IC_{50} value is 540 µg/ml by DPPH method. And by nitric oxide method IC_{50} vitamin C is 380 µg/ml, leaves extract is 560 µg/ml and bark extract is 540 µg/ml (37).

Qian He et al. reported that, ethanol and aqueous extract of guava leaf contains 575.3±15.5 and 511.6±6.2 mg GAE/g of total phenolic content. For antioxidant activity DPPH colorimetry at 515 nm and free radical scavenging activity are measured. If the concentration of sample is more the free radical scavenging effect also more. Ascorbic acid is used as a standard. The study proves that ethanolic leaves extract shows greater antioxidant activity than the water extract. Guava leaves extract contains natural antioxidants (38).

Rika Hartati et al. studied the antioxidant activity of leaves and fruit of crystal guava by DPPH, CUPRAC, and FRAP methods. The total phenolic content (TPC), total flavonoid content (TFC), correlation between the TPC and TFC with AAI DPPH, CUPRAC, and FRAP, and correlation between the 3 methods also investigated. Reflux method is used for the extraction using n-hexane, ethyl acetate, and ethanol. UV-visible spectrophotometry is used to evaluate the AAI DPPH, CUPRAC, FRAP, the TPC, and the TFC & Pearson's method is use to study the correlation. Antioxidant Activity Index (AAI) of leaves and fruit extracts of crystal guava is DPPH 0.33–56.46, CUPRAC 0.20–7.31, and FRAP 1.65–59.89. Ethanolic leaf extract contains higher TPC 49.55 ± 1.45 g GAE/100 g. n-hexane leaf extracts contains higher TFC 9.68 ± 0.210 g QE/100 g. TPC of leaves extract is positively correlated with AAI DPPH, CUPRAC, and FRAP. Leaves and fruit extract are positively correlated with AAI DPPH, AAI CUPRAC and AAI FRAP. Ethanolic extract of leaves and ethyl acetate extract of fruit of crystal guava gives highest antioxidant activity (39).

Research work on herbal formulations using guava leaves

Km.Bandana et al. formulated the gel using Carbopol 934 (5gm), Glycerine (1ml) honey (2ml) and extract of guava leaves and mulethi root. Three different concentrations of guava leaves and mulethi root extract are prepared i.e. 2%, 5%, 7% of guava leaves and 1%, 1.5%, 2% of mulethi root. *E. coli* is used for antibacterial study. 2% formulation shows higher zone of inhibition i.e. 11mm than 5% and 7%. For comparative study zone of inhibition of orasore gel is measured is 10mm. Guava leaves shows better antibacterial activity (40).

Sabir Shaikh et al. formulated the gel to treat the mouth ulcer by using guava leaves powder. The gel is effective against *Aspargillus aureus* and *Candida albicans.* The gel is formulated using guava leaves powder, carbopol 934, methyl paraben, propyl paraben, triethanolamine, distilled water. Three different formulations are prepared and concentration guava leaves powder is 0.5 – 2 %. Gel is transparent, homogeneous and the pH is 7-7.5. It has good spreadibility and extrudability properties. The zone of inhibition is 19±0.4, 20±0.6, 22±0.4 mm against *Aspargillus aureus* and 18±0.5, 19±0.6, 20±0.4 mm against *Candida albicans.* It is compared with marketed formulation and the zone of inhibition is 26±0.2 mm and 28±0.4 mm. The formulated herbal gel is effective against mouth ulcer (41).

Shaik Shaheena et al. formulated the toothpaste used to treat the dental problems. It contains guava leaves powder, *Acacia arabica* gum powder, stevia herb powder, sea salt, extra virgin coconut oil, peppermint oil. Three formulations are prepared as per concentration 10%, 15%, 20% (F1, F2, F3). The formulation is pale green, slightly bitter, pleasant and partially smooth. F3 shows better cleansing ability and antimicrobial activity against various bacteria such as *Bacillus subtilis, Proteus vulgaris, Streeptococcus mutans, Streeptococcus oralis* & the zone of inhibition is 0.8 cm, 1.1 cm, 0.9 cm, 0.6 cm. I t shows lower zone of inhibition against *Staphylococcus aureus* i.e. 0.5 cm (42).

Firdous Shaikh et al. prepared the hand sanitizer using guava leaves extract to control the pathogens. Other ingredients are carbopol, alcohol, glycerin, methyl paraben, deionised water, triethanolamine, perfume. The formulation is green, clear, non-irritant, pH 4-6. The formulation is effective against *E. coli* and *Bacillus subtilis.* The herbal hand sanitizer is inexpensive, biodegradable and environmentally safe (43).

Anjani Devi Chintin tagunta et al. formulated the jelly using guava leaves extract pectin, sugar and lemon juice. The guava jelly (GJ) shows better antibacterial activity against various bacteria such as P. vulgaris, S. mutans, B. subtilis and S.aureus and the zone of inhibition is 11.4 mm, 12.9 mm, 13.6 mm and 13.1 mm. GJ also shows better antioxidant activity against DPPH and hydroxyl radicals i.e. 42.38 % and 33.4 %. For comparative study ampicillin is used. Aqueous extract of guava leaves

contains quercetin, esculin, gallocatechin, gallic acid, citric acid, ellagic acid which gives antioxidant and anti-bacterial activities (44).

Nur Kamila Ramli et al. reported that the guava leaves extract act as a urease inhibitor. It contains quercetin in higher amount. Urea solution is prepared without guava leaves extract shows equal release of ammonia concentration starting from 10 minutes of incubation time until 90 minutes. Urea solution is prepared with mixture of urease-guava leaves extract shows the reduction in release of ammonia. The concentration of guava leaves extract is low, so the reduction of release of ammonia is also less i.e. 0.1mol/L and the releasing is also equal till the end of incubation time. The result shows that the guava leaves have the ability to reduce the ammonia concentration as it contains quercetin in high amount which is urease inhibitor (45).

Table 1: Presence of Phytochemicals in Different Extracts

Extracts	Phytochemicals
Water	Phenols, Tannins, Saponins, Terpenoids, Flavanoids, Glycocides, Carbohydrates, Oil and Fats, Cellulose, Steroids
Methanol	Alkaloids, Tannins, Flavanoids, Phenolic flavanoids, Ascorbic acid, Triterpenoids, Anthocyanins, Cardiac glycocides, Phenols, Glycocides
Ethanol	Alkaloids, Tannins, Flavanoids, Phenolic flavanoids, Ascorbic acid, Proteins, Starch, Terpenoids, Oil and Fats, Phenol, Carbohydrate, Cellulose, Steroids, Glycocodes.
Chloroform	Starch, Phenol, Oil and Fats, Terpenoids, Flavaniods, Carbohydrates, Cellulose, Tannins.
Benzene	Flavanoids, Starch, Oil and Fats, Phenol, Starch, Carbohydrates, Cellulose.
Hydroalcoholic	Alkaloids, Saponins, Steroids, Carbohydrates, Tannins, Flavanoids.
Acetone	Alkaloids, Flavanoids, Tannins, Triterpenes, Saponins.
Ethyl acetate	Saponins, Tannins, Flavonoids, Alkaloids, Carbohydrate, Terepnoid, Phenolic compound

Table 2: Concentration of Phytochemicals

Phytochemical	Concentration
Alkaloids	0.54 mg
Saponins	3.2 mg
Saponins (eth. Extract)	3.67 mg
Flavanoids (eth. extract)	6.42 mg
Phenolic flavanoids (meth. extract)	2.38 gm
Ascorbic acid (meth. extract)	36.5 mg

CONCLUSION:

Guava contains potential natural antioxidants. Guava leaves are reach in essential oil and quercetin which gives better antioxidant and antibacterial activity. Leaves show better antimicrobial activity that is why it can be used to treat various diseases. The fruit is rich in vitamin C, vitamin A, iron, phosphorous and minerals. It contains various phytochemicals. Various formulations can prepare using guava leaves with different dosage forms. It can be used to treat mouth ulcer dental problems. Guava leaves extract can be used as a biofertilizer to reduce release of ammonia.

Acknowledgement:

The authors are thankful to the Department of Pharmacognosy, Mahatma Gandhi Vidyamandir's Pharmacy College, Nashik, Maharashtra, India for their kind support and guidance for this review article.

Conflict of interests:

The authors declare that there is no conflict of interest.

REFERENCES:

1. K. R. Kirtikar, B. D. Basu & I.C.S., Indian Medicinal Plants, edited, revised, & mostly rewritten by E. Blatter, J. F. Caius & K. S. Mhaskar, Volume II, Published by Lalit Mohan Basu, M.B. 49, Leader Road, Allahabad, India. Page no. 1045-1048.
2. Dr. K. M. Nadkarni's Indian Materia Medica, Originally edited by The Late Dr. K. M. Nadkarni, revised and enlarged by A. K. Nadkarni, Forwarded to Coloneal Sir R. N. Chopra, Volume One, Published by Popular Prakashan, Page no. 1017-1019.
3. Sumra Naseer, Shabbir Hussain, Naureen Naeem, Muhammad Pervaiz, Madiha Rahman. The phytochemistry and medicinal value of Psidium guajava (guava). Clinical Phytoscience. 2018; 4:32.
4. SM Barbalho, Farinazzi-Machado FMV, de Alvares Goulart R, Brunnati ACS, Otoboni AM, et al. Psidium guajava (Guava): A plant of multipurpose medicinal applications. Medicinal and Aromatic Plants. 2012, Vol. 1 Issue 4
5. Adolf Nahrstedt. Polymeric proanthocyanidins from Psidium guajava. Scientia Pharmaceutica. 2005; 112-125.
6. Arain et al. Essential oil from Psidium guajava leaves: An excellent source of β-caryophyllene. Natural Product Communication. 2019: 1-5.
7. Elixabet Díaz-de-Cerio ,Vito Verardo Ana María Gómez-Caravaca Alberto Fernández-Gutiérrez , Antonio Segura-Carretero. Exploratory Characterization of Phenolic Compounds with Demonstrated Anti-Diabetic Activity in Guava Leaves at Different Oxidation States. Int J Mol Sci. 2016; 17(5): 699. doi: 10.3390/ijms17050699.
8. Batubara I, Suparto I H and Walundari N S. The best extraction technique for Kaemferol and Quercetin isolation from guava leaves (*Psidium guajava*). IOP Conf. Series: Earth and Environmental Science 58 (2017) 012060.
9. SM EI Sohafy, AM Metawalli, FM Harraz, AA Omar. Quantification of flavanoids of Psidium guajava L. Preparation by Planer Chromatography (HPTLC). Phcog Mag 2009; 5: 61-6.
10. Arima H, Danno G. Isolation of antimicrobial compounds from guava (*Psidium guajava* L.) and their structural elucidation. Bioscience, Biotechnology and Biochemistry. 2002; 66(8): 172701730.
11. Richa Singh, Sagar Bansal and Manoj Kumar Mishra. Formulation and evaluation of herbal oral gel containing extracts of powdered *Psidium guajava* Linn leaves with *Curcuma longa* Linn rhizomes to test mouth ulcer. International Journal of Drug Development and Research. 2020; 12(2): 150.
12. Gayatri, V., Kiruba, D. Preliminary phytochemical analysis of leaf powder extract of *Psidium guajava* L. International Journal of Pharmacognosy and Phytochemical Research. 2014; 6(2): 332-334.

13. Vikrant Arya, Narender Thakur, C. P. Kashyap. Preliminary phytochemical analysis of the extracts of *Psidium* leaves. Journal of Pharamacognosy and Phytochemistry. 2012; 1(1): 1-5.
14. S. Anbuselvi, Jeyanthi Rebecca. Phytochemical biochemical and antimicrobial activity of *Psidium guajava* leaf extract. Journal of Pharmaceutical Sciences and Research. 2017; 9(12): 2431-2433.
15. Mital Kaneria, Sumitra Chanda. Phytochemical and pharmacognostic evaluation of leaves of *Psidium guajava* L. (Myrtaceae). Pharmacognosy Journal. 2011; Vol 3 Issue 23 41-45.
16. Rinky Bisht, Sheetal Chanyal, Pavan kumar Agrawal. Antimicrobial and phytochemical analysis of leaf extract of medicinal fruit plants. Asian Journal of Pharmaceutical and Clinical Research. 2016; Volume 9 Issue 4; 131-136.
17. Biswas B, Rogers K, McLaughlin F, Daniels D, Yadav A. Antimicrobial activities of leaf extract of guava (*Psidium guajava* L.) on two gram-negative and gram positive bacteria. International Journal of Microbiology. 2013; Art. ID: 746165, 7 pages.
18. Das M, Goswami S, Antifungal and antibacterial property of guava (*Psidium guajava*) leaf extract: role of phytochemicals. Int J Health Sci Res. 2019; 9(2): 39-45.
19. Fumi Yamanaka, Tsutomu Hatano. Antibacterial effects guava tannins and related polyphenols on *Vibrio* and *Aeromonas* species. Natural Product Communications. 2008; 3(5): 711-720.
20. Steve Endeguele Ekon, Jean-De-DieuTamokou. Methanol leaves extract of *Psidium guajava* Linn. exhibited antibacterial and wound healing activities. International Journal Current Microbiology and Applied Science. 2018; 7(7): 4008-4023.
21. Gurnani P, Krishnan CGA, Gurnani R, Ghosh A, Shah A. Antibacterial activity of guava leaves extract against Lactobacillus acidophilus: An in-vitro study. International Journal of Oral Health and Medical Research. 2016; 2(6): 37-40.
22. Shetty YS, Shankarapillai R, Vivekanandan G, Shetty RM, Reddy CS, Reddy H, Mangalekar SB. Evaluation of the efficacy of guava extract as an antimicrobial agent on periodontal pathogens. Journal of Contemporary Dental Practice. 2018; 19(6): 690-697.
23. Mushtaq M, Daud M, Khattak S, Samrana S. In vitro antimicrobial activity of guava leaves extract against important bacterial and fungal strain. International Journal of Bioscience. 2014; 10(4): 188-192.
24. Elisa Friska Romasi, Adolf J. N. Parhusip, Yuniwaty. Study of antimicrobial activity from guava (*Psidium gua*java L.) leaf extract towards pathogenribesic microbes. Proceeding Biotech.
25. Indriyani Nur, Santi and Agus Kurnia. Efficacy of guava (Psidium guajava) leaves extract to prevent vibriosis in white shrimp (*Litopenaeus vannamei*). Research Journal of Medicinal Plants. 2019; 13(4): 136-144.
26. Manisha Pandey, Afifa Qidwai, Rajesh Kumar, Anand Pandey, Shashi Kant Shukla, Ashutosh Pathak and Anupam Dikshit. Pharmacological and antibacterial aspect of Psidium guajava L. against Acne vulgaris. International Journal of Pharmaceutical Sciences and Research. 2017; 8(1): 145-150.
27. Goncalves F. A., Andrade Nedo M., Bezerra J. N. S., Macrade A., Sousa O. V., Fonteles-Filho A. A. & Vieira R. H. S. F. Antibacterial activity of guava , *Psidium guajava* Linnaeus, leaf extract on diarrhea- causing enteric bacteria isolated from Seabob shrimp. *Xiphopenaceus kroyeri* (Heller). Rev. Inst. Med. Trop. S. Paulo. 2008; 50(1): 11-15.
28. Ekeleme Kenneth, Tsaku Paul, Nkene Istifanus, Ufomadu Uba, Abimiku Rejoice, Oti Victor and Sidi Mohammed. Phytochemcal analysis and antibacterial activity of *Psidium guajava* L. leaf extracts.GSC Biological and Pharmaceutical Sciences. 2017; 01(02): 013-019.
29. Jongkwon Seo, Soojung Lee, Marcus L. Elam, Sarah A. Johnson, Jonghoon Kang, Bahram H. Arjmandi. Study to find the best extraction solvent for use with guava leaves (*Psidium guajava* L.) for high antioxidant efficacy. Food Science & Nutrition. 2014; 2(2): 174-180.
30. Julio Cesar Camarena-Tello, Hector Eduardo Martinez-Flores, Ma.Guadalupe Garnica-Romo,Jose Saul Padilla-Ramiewz, Alfredo Saavedra-Molina,Osvaldo Alvaerez-Cortes, Maria Carmen Bartolomo-Camacho and Jose Octavio Rodiles-Lopez. Quantification of Phenolic Compounds and In Vitro Radical Scavenging Abilities with Leaf Extracts from Two Varieties of Psidium guajava L. MDPI. 2018; 7:34.
31. K. Iamjud, N. Banyen, U. Boonprakob and K. Thaipong. Ascorbic Acid, Total Phenolics and Antioxidant Activity of Guava Leaf Extracts. Acta Horticulture. 2014; 366-372.
32. Samir M. El-Amin, Maher A. M. Hashash, Allia M. Abdou, Amal M. Saad, Mohamed S. Abdel-Aziz and Asmaa S. Mohamed. Antimicrobial and antioxidant activities of *Psidium guajava* leaves growing in Egypt. Scholars Research Library. 2016; 8(12): 27-33.
33. Chibuike Ibe, Conrad Chimezie Jacobs, Chinedu Imo, Kelechi Uzoma Osuocha and Monday Uchenna Okoronkwo. Evaluation of the Antioxidant Activities of *Psidium guajava* and *Aloe vera*. British Journal of Pharmaceutical Research. 2014; 4(3): 397-406.
34. Ravi Narayan Venkatachalam, Kanchanlata Singh, Thakamani Marar. Phytochemica screening and in vitro antioxidant activity of *Psidium guajava*. Free Radicals and Antioxidants. 2012; Vol. 2 / Issue 1/ Jan-Mar.
35. Wei Cai Lee,, Roziahanim Mahmud, Suthagar Pillai, Shanmugapriya Perumal, Sabariah Ismail. Antioxidant Activities of Essential Oil of *Psidium guajava* L. Leaves. APCBEE Procedia. 2012; 2: 86 – 91.
36. Deepa Philip C, Indira Kumari R, Lavanya B. Phytochemical analysis, antioxidant and anti microbial activity of white & pink *Psidium guajava* Linnaeus. International Journal of Current Pharmaceutical Research.2015; Vol. 7, Issue 2, 29-31.
37. Subba Rao Ch, Arun Kumar S, Javed Ali, Priyadarshini P, Keerthi R, Nivedita L, Priyanka D. In vitro antioxidant activity of *Psidium guajava* Linn. by using ethanolic extract fraction of leaves and bark. Adv Cell Sci Tissue Cult. 2018; volume 2 Issue 1 19-22.
38. Qian He, Nihorimbere Venant. Antioxidant power of phytochemicals from *Psidium guajava* leaf. Journal of Zhejiang University Science. 2004; 5(6): 676-683.
39. Rika Hartati , Hashifah I. Nadifan , and Irda Fidrianny. Crystal Guava (*Psidium guajava* L. "Crystal"): Evaluation of in vitro antioxidant capacities and phytochemical content. The Scientific World Journal. 2020; Article ID 9413727, 7 pages doi.10.1155/2020/9413727.
40. Km. Bandana, Sachin Kumar, Manoj Kumar Sagar, Himani Tyagi. Formulation and evaluation of herbal gel of guava leaves and liquorice roots extract for using mouth ulcer. Journal of Critical Reviews. 2020; 18(7): 3097-33110.
41. Shaikh Sabir, Shete Amol, Doijad Rajendra. Formulation and evaluation pharmaceutical aqueous gel of powdered guava leaves for mouth ulcer treatment. PharmaTutor. 2018; 6(4): 32-38.
42. Shaik Shaheena, Anjani Devi Chintagunta, Vijaya Ramu Dirisala and N. S. Sampath Kumar. Extraction of bioactive compounds from *Psidium guajava* and their application in dentistry. AMB Express. 2019; 9:208 https://doi.org/10.1186/s13568-019-0935-x.
43. Firdous Shaikh, Priyanka Bhosale, Snehal More. Formulation and evaluation of herbal hand sanitizer using *Psidium guajava* leaves extract. International Journal of Pharmaceutical Sciences Review and Research. 2020; 62(2): 37-39.
44. N.S. Sampath Kumar, Norizah Mhd Sarbon, Sandeep Singh Rana, Anjani Devi Chintagunta, S. Pratibha, Satheesh Kumar Ingilala, S. P. Jeevan Kumar, B. Sai Anvesh and Vijaya Ramu Dirisala. Extraction of bioactive compounds from *Psidium guajava* and its utilization in preparation of jellies. AMB Express. 2021; 11:36 https://doi.org/10.1186/s13568-021-01194-9.
45. Nur kamila Ramli, Zahid Majeed, Anis Suhaila Shuib, Nurlidia Mansor, Zakaria Man. The potential of quercetin in *Psidium guajava* L. leaves extract as bioinhibitor for controlled released fertilizer. Advanced Materials Research. 2014; Vol. 970; 16-18.