Review article

Medicinal plant genetic resources of Bangladesh exhibiting anti-dengue activity: A review

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ABSTRACTS

Dengue fever, caused by the arthropod-borne dengue virus, has experienced a global increase, with the number of cases rising from 500,000 to 5.2 million and over 5000 deaths within the last two decades. Although dengue incidence in Bangladesh fluctuated from 1964 to 1999, peaking in 2000, it has since spread, impacting thousands of lives and causing diseases. There is currently no (or limited availability of) effective dengue vaccination and antiviral medication. A comprehensive review was conducted to identify the local medicinal plants with anti-dengue activity. A total of 73 species belonging to 42 families possess anti-dengue properties; some also have insecticidal properties, especially against Aedes species. Medicinal plants possess different types of secondary metabolites, for example, phenolic derivatives, alkaloids, flavonoids, terpenoids, and polysaccharides with compound-specific dengue preventing mechanisms. The conversion of these medicinal plants into prescription drugs to treat dengue infections requires more clinical investigation.

Key words: Alkaloids, dengue, flavonoids, polysaccharides, terpenoids, total phenolics

INTRODUCTION

Dengue fever is the most emerging viral human disease caused by the arthropod-borne dengue virus (DENV), which belongs to the genus *Flavivirus* in the family *Flaviviridae* (Goel *et al*., 2004). Dengue incidence has surged globally, with the World Health Organization (WHO) reporting a tenfold increase from 500,000 to 5.2 million cases between 2000 and 2019; the year 2019 experienced an all-time high, with cases reported in 129 countries (https://www.who.int/emergencies/disease-outbreak-news/item/2023-DON498). Since the start of 2023, more than 5000 dengue-related deaths and nearly a historic five million cases have been reported in more than 80 countries and territories due to continuous transmission and an unanticipated increase in dengue infections (https://www.who.int/emergencies/disease-outbreak-news/item/2023-DON498). With 40% of the world's population living in areas at risk for transmission, dengue virus infection is a leading cause of illness in the tropics and subtropics (https://www.cdc.gov/dengue/training/cme/ccm/page52245.html). About 8 million people worldwide may be afflicted by dengue and malaria in 2080 (Hillary *et al*., 2024). The dengue virus is spread through two species of *Aedes, A. aegypti* and *A. albopictus*, mosquitoes (Hossain *et al*., 2023). When an infected mosquito bites a human, it transmits the disease. There are four serotypes of DENV: DENV-1, DENV-2, DENV-3, and DENV-4. Among these, DENV-2 is more lethal than any other serotype (Saleh and Kamisah, 2021). Infection of one serotype confers permanent immunity to that serotype and only temporary immunity to the other serotypes; subsequent infections with a different serotype raise the risk of developing severe dengue (Reich *et al.*, 2013). Symptoms of dengue fever include fever, headache, joint, and muscle pain (Gubler, 2006). Chronic symptoms include dengue fever to severe hemorrhagic, characterized by low platelet levels and blood plasma leakage, also known as dengue shock syndrome (Pigili and Runja, 2014). First infections with DENV-1 or DENV-3 often led to more severe illness than main infections with DENV-2 or DENV-4 (Tang *et al*., 2012).

Dengue incidence in Bangladesh was intermittently reported from 1964 to 1999. The first significant dengue outbreak happened in 2000, and since then, it has spread throughout the country, affecting thousands of people's quality of life and creating diseases (Hossain *et al.*, 2023). According to the most recent official statistics (November 22, 2024), at least 438 individuals died from connected issues in 2024, while 84,826 patients were admitted to hospitals across the country (https://dashboard.dghs.gov.bd/pages/heoc_dengue_v1.php). The climatic conditions of Bangladesh are favourable for dengue infection. Although dengue is endemic in Bangladesh, the current dengue surge is unusual in terms of seasonality and the early sharp increase compared to previous years, where the surge typically starts around late June (Hossain *et al.* 2023). The case fatality rate (CFR) so far this year is relatively high compared to previous years for the full-year period. The pre-monsoon *Aedes* survey shows that the density of mosquitoes and the number of potential hotspots are at the highest level in the past five years (WHO, 2023). Hossain *et al*. (2023) recently conducted a thorough analysis of the entire dengue situation, including illness burden, clinical spectrum, seroprevalence, circulating serotypes/genotypes, and spatial distribution since the first outbreak was documented in Bangladesh.

Dengue fever does not currently have a specific treatment. Therefore, with the rapid expansion of dengue disease, it is imperative to create efficient preventative and control strategies, such as antiviral medications and dengue vaccinations. However, there is currently no effective dengue vaccination or antiviral medication (Zandi *et al*., 2011; Tang *et al*., 2012) or limited availability (a Sanofi Pasteur-developed dengue vaccine has been approved in 24 nations and included in public vaccination programs in Brazil and the Philippines) (Hossain *et al*., 2023). Typically, dengue patients get supportive care until they fully recover without particular therapeutic interventions. Traditional herbal remedies have been thoroughly studied as an alternative treatment due to the adverse (or disastrous) side effects of synthetic medications and the increasing resistance of bacteria to conventional antimicrobial therapy. About 80% of the population in developing countries, especially in Asia and Africa, use natural products from plants for their primary healthcare (WHO, 2020). Plants and chemicals produced by them continue to be valuable sources for developing novel antiviral medications due to their high accessibility in nature and anticipated low side effects. Several medicinal plants have been shown to have significant antiviral properties at various stages of viral development, and many have been used to treat viral infections in both humans and animals, including DENV infection (Ganjhu *et al*., 2015; Sarwar *et al*., 2022; Firuj *et al*., 2023). Bangladesh is rich in medicinal plant genetic resources (Sarwar, 2020); therefore, this study aims to identify the medicinal plants of Bangladesh, plant parts used, and active constituents that could be used for dengue disease treatments.

METHODOLOGY

A narrative literature review was conducted on the possibility of using medicinal plants in Bangladesh to treat dengue. Different electronic sources of databank – PubMed, SpringerLink, MDPI link, ResearchGate, Google and Google Scholar, ScienceDirect, etc.—were searched for the article. Bangladeshi articles were searched in the BanglaJol database (an exclusive database of Bangladeshi Journals) with a combination of keywords “dengue”, “antiviral”, “medicinal plants”, “Bangladesh”, etc. Articles published in other languages except English and editorials and comments not subjected to peer review were excluded. Internationally recognised websites such as Plants of the World Online (https://powo.science.kew.org/), the International Plant Names Index (https://www.ipni.org/), and World Flora Online (https://www.worldfloraonline.org/) have been checked for current nomenclature and family delimitation.

RESULTS AND DISCUSSION

Medicinal plants of 73 species belonging to 42 families could be used to treat dengue fever (Table 1). With seven species (9.59% of total), the family Lamiaceae emerged as the largest source of anti-dengue plants, followed by Fabaceae (8.22%; six species), Asteraceae and Zingiberaceae (5.48%; four species each) (Figure 1). Twenty-seven families were represented by a single species each (Table 1). In other publications, Lamiaceae is also identified as one of the most useful families for treating dengue and other viral diseases. For example, according to Saleh and Kamisah (2021), 54 species from 31 families exhibited anti-dengue activity; the most prominent representatives were the Lamiaceae (10.5%), Asteraceae (9.9%), Aristolochiaceae, and Loganiaceae (each 7.2%).

In terms of plant parts used, more than one plant part was used for 18 plant species (24.66% of the total), followed by the whole plant (13.70%; 10 species) (Table 1; Figure 2). Individually, leaves were the most common (36.99%; 27 species) plant part used, followed by fruits (5.48%; 4 species) (Table 1; Figure 2).

Medicinal plants possess different types of secondary metabolites, for example, phenolic derivatives (4-hydroxy panduratin, geraniin, α-mangostin, methyl gallate), alkaloids (castanospermine, hirsutine, palmatine), flavonoids (chartaceones, pectolinarinandacactein-7-O-rotinosides, catechin, 5-hydroxy-7-methoxy-6-methyl flavanone), terpenoids (betulinic acid 3β-caffeate, lupeol acetate, celastrol, andrographolide), and polysaccharides (fucoidan, carrageenan, galactomanns) (Table 1; Altamish *et al*., 2022; Dhiman *et al*., 2022); although the mechanism of preventing dengue infections is different (Figure 3) and compound-specific. Saleh and Kamisah (2021) enumerated 51 bioactive substances in total with different degrees of anti-dengue activity, including seven polysaccharides, 14 flavonoids, 17 phenolics and flavonoid glycosides and derivatives, two alkaloids, a saponin, six terpenoids, and four phenolic acids. Quercetin, one of several compounds, showed significant anti-DENV-2 inhibitory effects (Zandi *et al*., 2011). More importantly, both DENV and SARS-CoV viral infections are inhibited by quercetin (Saleh and Kamisah, 2021). The plant bioactive compounds demonstrate an antiviral response either directly or via inducing immunomodulatory response cascades against DENV at various stages of infection, such as inhibition of viral entry and/or viral cell adhesion, viral adsorption, intracellular replication, proliferation, and cellular metabolism (Figure 3; Loaiza-Cano *et al*., 2021; Dhiman *et al*., 2022). Certain medicinal plants, such as *Houttuynia cordata* and *Boesenbergia rotunda* and their bioactive compounds effectively inhibit both DENV and SARS-CoV infections, despite their distinct viral families, structures, entry mechanisms, replication, and pathogenicity (Saleh and Kamisah, 2021). Flavonoids also facilitate the entry of infectious virus particles into phagocytes, immune cells that generate several proinflammatory cytokines involved in the pathophysiology of severe dengue (Loaiza-Cano *et al*., 2021). Additionally, plant metabolites aid in lowering the antigen burden and regulating several host immunological components (Dhiman *et al*., 2022). Plant-mediated immunomodulation results in increased platelet counts, phagocytic pathway activation, and controlled cytokine production.

The insecticidal qualities of medicinal plants, such as *A. paniculata*, *A. calamus*, *A. indica*, *C. citratus*, etc., are another important feature that makes them a viable and environmentally benign alternative to controlling *Aedes* mosquitoes and dengue infection (Table 1; Senthil-Nathan, 2020; Saleh and Kamisah, 2021; Dhiman *et al*., 2022). Medicinal plant extracts have larvicidal, pupicidal, ovicidal, and adulticidal properties, and act as repellents, toxins, feeding deterrents, growth retardants, and bite protectors. These extracts target cellular mechanisms, potentially disrupting vector mosquitoes' functions by disturbing proteins, ion channels, nucleic acids, and other cellular components; reducing enzyme levels, affecting metamorphosis and body tissues like epithelium layer, muscles, midgut, and nervous systems (Hillary *et al*., 2024). Medicinal plant extracts, as bioinsecticides, are effective alternatives to chemical insecticides in integrated mosquito management programs due to their multiple modes of action and synergic compounds, which lower the possibility of development of resistance to it (Demirak and Canpolat, 2022). These products of plant origin offer the combined benefits of being affordable, safe for non-target creatures, biodegradable, and environmentally benign. Moreover, some medicinal plants are still utilised in traditional ways for their anti-dengue qualities and have not yet been studied for scientific validation (Table 1; Dhiman *et al*., 2022).

CHALLENGES AND FUTURE DIRECTIONS

The absence of an effective and widely accessible dengue vaccine and antiviral medications, along with difficulties in outbreak prediction and management in Bangladesh, coupled with fluctuating incidence, necessitates localized strategies and the utilization of medicinal plants with anti-dengue properties. Constraints for the integration of traditional medicine into the modern healthcare system could be divided into organizational, legal, policy, and socio-cultural. The efficacy, safety, uniformity, and quality of conventional medicine are sometimes a matter of debate. Traditional approaches to prescribing medicinal plants with anti-dengue properties are yet to be scientifically validated. Extensive research is, therefore, required to assess immunologic potentials, phytochemical richness, and clinical probing of these plants for effective medicine development. Moreover, comparison among medicinal plants (and/or phytochemicals) could be an interesting topic for commercial biopesticides development. Collaboration between traditional medicine practitioners and modern pharmaceutical researchers should be fostered to integrate traditional knowledge with contemporary science effectively.

CONCLUSION

This review shows the enormous potential of Bangladeshi medicinal plants, available in other parts of the world as well, for the treatment of dengue. Several interesting medicinal plants have been identified that could be developed into prescription medications to treat dengue infections. To create a successful medication, further clinical research is needed to evaluate the immunologic potential of plants and their phytochemical diversity as well.

CONFLICT OF INTEREST STATEMENT

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

REFERENCES:

Altamish, M., Khan, M., Baig, M.S., Pathak, B., Rani, V., Akhtar, J., Khan, A.A., Ahmad, S. and Krishnan, A. 2022. Therapeutic potential of medicinal plants against dengue infection: a mechanistic viewpoint. *ACS Omega,* **7**: 24048−24065. doi: 10.1021/acsomega.2c00625

Babbar, R., Kaur, R., Rana, P., Arora, S., Behl, T., Albratty, M., Najmi, A., Meraya, A.M., Alhazmi, H.A. and Singla, R.K. 2023. The current landscape of bioactive molecules against DENV: A systematic review. *Evid.-Base. Comp. Alter. Med*., **2023**: 2236210. doi: 10.1155/2023/2236210

Batoro, J. and Siswanto, D. 2017. Ethnomedicinal survey of plants used by local society in Poncokusumo district, Malang, East Java Province, Indonesia. *Asian J. Med. Biol. Res*., 3:158-167. doi: 10.3329/ajmbr.v3i2.33563

Bhuiyan, F.R., Howlader, S., Raihan, T. and Hasan, M. 2020. Plants metabolites: Possibility of natural therapeutics against the COVID-19 pandemic. *Front. Med. (Lausanne)*, **7**: 444. doi: 10.3389/fmed.2020.00444

Bradacs, G., Heilmann, J. and Weckerle, C.S. 2011. Medicinal plant use in Vanuatu: A comparative ethnobotanical study of three islands. *J. Ethnopharmacol.*, **137**: 434-448. doi: 10.1016/j.jep.2011.05.050

Bussmann, R.W. and Sharon, D. 2006. Traditional medicinal plant use in Northern Peru: Tracking two thousand years of healing culture. *J. Ethnobiol. Ethnomed.*, **2**: 60-70. doi: 10.1186/1746-4269-2-47

Chand, R.R., Devi, S.S., Kumari, S.S., Kumar, S.S., Goundar, N.N., Naranyan, N. and Chandra, P. 2018. Traditional use of medicinal plants among selected villages in Fiji Islands: A review. *Pac. Med. Stud. J.*, **1**: 10–20.

Deep, P., Srivastava, V. and Verma, S. 2018. Current perspectives of medicinal plants having anti dengue potential. *Int. J. Pharm. Sci. Rev. Res.*, **49**: 91–96.

Demirak, M.Ş.Ş. and Canpolat, E. 2022. Plant-based bioinsecticides for mosquito control: impact on insecticide resistance and disease transmission. *Insects*, **13**, 162. doi: 10.3390/insects13020162.

Desai, A., Desai, C., Desai, H. and Mansuri, A. 2020. Possible role of medicinal plants in COVID19 - A brief review. *Int. J. Sci. Dev. Res*., **5**: 205-209.

Dhiman, M., Sharma, L., Dadhich, A., Dhawan, P. and Sharma, M.M. 2022. Traditional knowledge to contemporary medication in the treatment of infectious disease dengue: A review. *Front. Pharmacol*., **13**: 750494. doi: 10.3389/fphar.2022.750494

Divyaa, M., Vijayakumara, S., Chen, J., Vaseeharana, B. and Durán-Larac, E.F. 2020. South Indian medicinal plants can combat deadly viruses along with COVID-19? - A review. *Microb. Path*., **148:** 104277. doi: 10.1016/j.micpath.2020.104277

Fang, C.Y., Chen, S.J., Wu, H.N., Ping. Y.H., Lin, C.Y., Shiuan, D., Chen, C.L., Lee, Y.R. and Huang, K.J. 2015. Honokiol, a lignan biphenol derived from the *Magnolia* tree, inhibits Dengue Virus Type 2 infection. *Viruses*, **7**(9): 4894-910. doi: 10.3390/v7092852

Firuj, A., Aktar, F., Akter, T., Chowdhury, J.A., Chowdhury, A.A., Kabir, S., Büyüker, S.M. and Amran, M.S. 2023. Anti-viral activity of 62 medicinal plants, herbs and spices available in Bangladesh: A mini review. *Dhaka Univ. J. Pharm. Sci*., **22**(2): 219-238. doi: 10.3329/dujps.v22i2.67408

Fiscal, R.R. 2017. Ethnomedicinal plants used by traditional healers in Laguna, Philippines. *Asia Pac. J. Multidiscip. Res.*, **5**: 132-137.

Ganjhu, R.K., Mudgal, P.P., Maity, H., Dowarha, D., Devadiga, S., Nag, S. and Arunkumar, G. 2015. Herbal plants and plant preparations as remedial approach for viral diseases. *Virus Dis.*, **26**: 225-236. doi: 10.1007/s13337-015-0276-6

Gascon, M.G. 2011. Traditional ecological knowledge system of the matigsalug tribe in mitigating the effects of dengue and malaria outbreak. *Asian J. Health*, **1**: 160-171. doi: 10.7828/ajoh.v1i1.161

Goel A, Patel DN, Lakhani KK, Agarwal SB, Agarwal A, Singla S, Agarwal R. 2004. Dengue fever—a dangerous foe. *J. Indian Acad. Clin. Med.*, **5**(3): 247-258.

Gubler, D.J. 2006. Dengue/dengue haemorrhagic fever: History and current status. In: *Proc. Novartis Foun. Symp.* Vol. **277**, Wiley Online Library: Chichester, UK. p. 3.

Hajdu, Z. and Hohmann, J. 2012. An ethnopharmacological survey of the traditional medicine utilized in the community of Porvenir, Bajo Paraguá Indian Reservation, Bolivia. *J.*

Ethnopharmacol., **139**: 838-857. doi: 10.1016/j.jep.2011.12.029

Hillary, V.E., Ceasar, A.S. and Ignacimuthu, S. 2024. Efficacy of plant products in controlling disease vector mosquitoes, a review. *Entomol. Exp. Appl*., **172**: 195-214.doi: 10.1111/eea.13401

Hossain, M., Sharif, R., Mamun, A.H., Rayhana, N., Begum, K., Tripty, F., Keya, A.S., Shetu, S., Ema, S.P. and Al-Nahain, A. 2014. Phytomedicines of traditional health-care professionals in the vicinity of Lawachara Forest Reserve, Moulvibazar district, Bangladesh. *Am. Eurasian J. Sustain. Agric.*, **8**: 51-60.

Hossain, M.S., Al Noman, A., Al Mamun, S.M.A. and Al Mosabbir, A. 2023. Twenty-two years of dengue outbreaks in Bangladesh: epidemiology, clinical spectrum, serotypes, and future disease risks. *Trop. Med. Heal.*, **51**: 37. doi: 10.1186/s41182-023-00528-6

Ichsyani, M., Ridhanya, A., Risanti, M., Desti, H., Ceria, R., Putri, D.H., Sudiro, T.M. and Dewi, B.E. 2017. Antiviral effects of *Curcuma longa* L. against dengue virus *in-vitro* and *in-vivo*. *In: IOP Conf. Ser.: Earth Environ. Sci.*, **101:** 012005.

Islam, M.K., Saha, S., Mahmud, I., Mohamad, K., Awang, K., Uddin, S.J., Rahman, M.M. and Shilpi, J.A. 2014. An ethnobotanical study of medicinal plants used by tribal and native people of Madhupur forest area, Bangladesh. *J. Ethnopharmacol.*, **151**: 921-930. doi: 10.1016/j.jep.2013.11.056

Joshi, R.K., Agarwal, S., Patil, P., Alagarasu, K., Panda, K., Prashar, C., Kakade, M., Davuluri, K.S., Cherian, S., Parashar, D., Pandey, K.C. and Roy, S. 2023. Effect of *Sauropus androgynus* (L.) Merr. on dengue virus-2: An in vitro and in silico study. *J. Ethnopharmacol*., **304**: 116044. doi: 10.1016/j.jep.2022.116044

Julsrigival, J., Sirisa-ard, P., Julsrigival, S. and Akarchariya, N. 2021. Antiviral medicinal plants found in Lanna traditional medicine, *Chinese Herb. Med.*, **13**(4): 494-501. doi: 10.1016/j.chmed.2021.09.006

Kandowangko, N.Y., Latief, M. and Yusuf, R. 2018. Inventory of traditional medicinal plants and their uses from Atinggola, North Gorontalo district, Gorontalo province, Indonesia. *Biodivers*, **19**: 2294-2301. doi: 10.13057/biodiv/d190637

Kiat, T. S. Pippen, R., Yusof, R., Ibrahim, H., Khalid, N. and Rahman, N.A. 2006. Inhibitory activity of cyclohexenyl chalcone derivatives and flavonoids of fingerroot, *Boesenbergia rotunda* (L.), towards dengue-2 virus NS3 protease. *Bioorg. Med. Chem. Lett.*, **16**: 3337-3340. doi: 10.1016/j.bmcl.2005.12.075

Klawikkan, N., Nukoolkarn, V., Jirakanjanakit, N., Yoksan, S., Wiwat, C. and Thirapanmethee, K. 2011. Effect of Thai medicinal plant extracts against dengue virus *in vitro*. *Mahidol Univ. J. Phar. Sci.*, **38**(1-2): 13-18.

Loaiza-Cano, V., Monsalve-Escudero, L.M., Filho, C.d.S.M.B., Martinez-Gutierrez, M. and de Sousa, D.P. 2021. Antiviral role of phenolic compounds against dengue virus: a review. *Biomolecules,* **11**: 11. doi.: 10.3390/biom11010011

Morshed, N., Reza, R., Samdani, M.N. and Asaduzzaman, M. 2022. Phytochemicals from Bangladeshi medicinal plants potentially targeting non-structural protein 2/non-structural protein 3 chimera of dengue virus: An in-silico study. *Dhaka Univ. J. Phar. Sci.*, **20**(3): 417-426. doi.:10.3329/dujps.v20i3.59805

Parida, M.M., Upadhyay, C., Pandya, G. and Jana, A.M. 2002. Inhibitory potential of neem (*Azadirachta indica* Juss) leaves on dengue virus type-2 replication. *J. Ethnopharmacol*., **79**: 273-278.

Pigili, R.K. and Runja, C. 2014. Medicinal plants used in dengue treatment: An overview. *Int. J. Chem. Nat. Sci*., **2**(1): 70-76.

Pratheeba, T., Taranath, V., Sai Gopal, D. and Natarajan, D. 2019. Antidengue potential of leaf extracts of *Pavetta tomentosa* and *Tarenna asiatica* (Rubiaceae) against dengue virus and its vector *Aedes aegypti* (Diptera:

Culicidae). *Heliyon*, **5**(11): e02732. doi: 10.1016/j.heliyon.2019.e02732

Rahmatullah, M., Jahan, R., Azam, F.M.S., Hossan. S., Mollik, M.A.H. and Rahman, T. 2011. Folk medicinal uses of Verbenaceae family plants in Bangladesh. *Afr. J. Tradit. Complement. Altern. Med.*, **8**: 53-65. doi: 10.4314/ajtcam.v8i5S.15

Rahmatullah, M., Mollik, M.A.H., Azam, A., Islam, M.R., Chowdhury, M.A.M., Jahan, R., Chowdhury, M.H. and Rahman, T. 2009. Ethnobotanical survey of the santal tribe residing in Thakurgaon District, Bangladesh. *Am. Eurasian J. Sustain. Agric.*, **3**: 889-898.

Reich, N.G., Shrestha, S., King, A.A., Rohani. P., Lessler. J., Kalayanarooj, S., Yoon, I.K., Gibbons, R.V., Burke, D.S. and Cummings, D.A. 2013. Interactions between serotypes of dengue highlight epidemiological impact of cross-immunity. *J. R. Soc. Interface,* **10**(86): 20130414. doi: 10.1098/rsif.2013.0414

Rosmalena, R., Elya, B., Dewi, B.E., Fithriyah, F., Desti, H., Angelina, M., Hanafi, M., Lotulung, P.D., Prasasty, V.D. and Seto, D. 2019. The antiviral effect of Indonesian medicinal plant extracts against dengue virus *in vitro* and *in silico*. *Pathogens*, **8**(2): 85. doi.: 10.3390/pathogens8020085

Saleh, M.S.M. and Kamisah, Y. 2021. Potential medicinal plants for the treatment of dengue fever and severe acute respiratory syndrome-Coronavirus. *Biomolecules,* **11**: 42. doi.: 10.3390/biom11010042

Sarah, D.A., Diletta, S., Lucia, S., Federica, P., Denise, P.I., Pasquale, F. and Serena, D. 2020. Review: the use of antimalarial drugs against viral infection. *Microorganisms,* **8**: 85. doi.:10.3390/microorganisms8010085

Sarker, M.M.R., Khan, F. and Mohamed, I.N. 2021. Dengue fever: therapeutic potential of *Carica papaya* L. leaves. *Front. Pharmacol*. **12**: 610912. doi: 10.3389/fphar.2021.610912

Sarwar, A.K.M. Golam, Ashrafuzzaman, M. and Pramanik, M.H.R. 2022. COVID-19 pandemic: minor fruits and medicinal plants. *In: Abs. 6th Int. Symp. Minor Fruits Med. Arom. Plants,* Cooch Behar, India, November 24-26.

Sarwar, A.K.M. Golam. 2020. Medicinal and aromatic plant genetic resources of Bangladesh and their conservation at the Botanical Garden, Bangladesh Agricultural University. *Int. J. Minor Fruits Med. Aroma. Plants,* **6**: 13-19.

Senthil-Nathan, S. 2020. A review of resistance mechanisms of synthetic insecticides and botanicals, phytochemicals, and essential oils as alternative larvicidal agents against mosquitoes. *Fron. Physiol*., **10**: 1591. doi: 10.3389/fphys.2019.01591

Sharma, B.K., Klinzing, D.C. and Ramos, J.D. 2015. *Zingiber officinale* Roscoe aqueous extract modulates matrix metalloproteinases and tissue inhibitors of metalloproteinases expressions in Dengue virus infected cells: Implications for prevention of vascular permeability. *Trop. J. Pharm. Res.*, **14**(8): 1371-1381.

Tang, L.I.C., Ling, A.P.K., Koh, R.Y., Chye, S.M. and Voon, K.G.L. 2012. Screening of anti-dengue activity in methanolic extracts of medicinal plants. *BMC Comp. Alter. Med*., **12**: 3. doi:10.1186/1472-6882-12-3

Wei, X., Xu, X., Chen, Z., Liang, T., Wen, Q., Qin, N., Huang, W., Huang, X., Li, Y., Li, J., He, J., Wei, J. and Huang, R. 2018. Protective effects of 2-dodecyl-6 methoxycyclohexa-2,5-diene-1,4-dione isolated from *Averrhoa carambola* L. (Oxalidaceae) roots on neuron apoptosis and memory deficits in Alzheimer's disease. *Int. J. Exp. Cell. Physiol. Biochem. Pharmacol.,* **49**: 1064-1073.

WHO (World Health Organization). 2012. Dengue and severe dengue. Fact Sheet. http://www.who.int/mediacentre/factsheets/fs117/en/

WHO (World Health Organization). 2020. Traditional, Complementary and Integrative Medicine. https://www.who.int/health-topics/traditional-complementary-and-integrative-medicine#tab=tab_1

WHO (World Health Organization). 2023. Disease Outbreak News; Dengue in Bangladesh. https://www.who.int/emergencies/disease-outbreak-news/item/2023-DON481

Wilson, D.K., Shyamala, G., Paulpandi, M., Narayanasamy, A., Siram, K., Karuppaiah, A. and Sankar, V. 2021. Development and characterization of phytoniosome nano vesicle loaded with aqueous leaf extracts of *Justicia adhatoda* and *Psidium guajava* against dengue virus (DEN-2). *J. Clust. Sci.*, **32**, 297-304.

Zandi, K., Teoh, B.-T., Sam, S.-S., Wong, P.-F., Mustafa, M.R. and AbuBakar, S. 2011. Antiviral activity of four types of bioflavonoid against dengue virus type-2. *Virol. J.*, **8**: 560. doi:10.1186/1743-422X-8-560

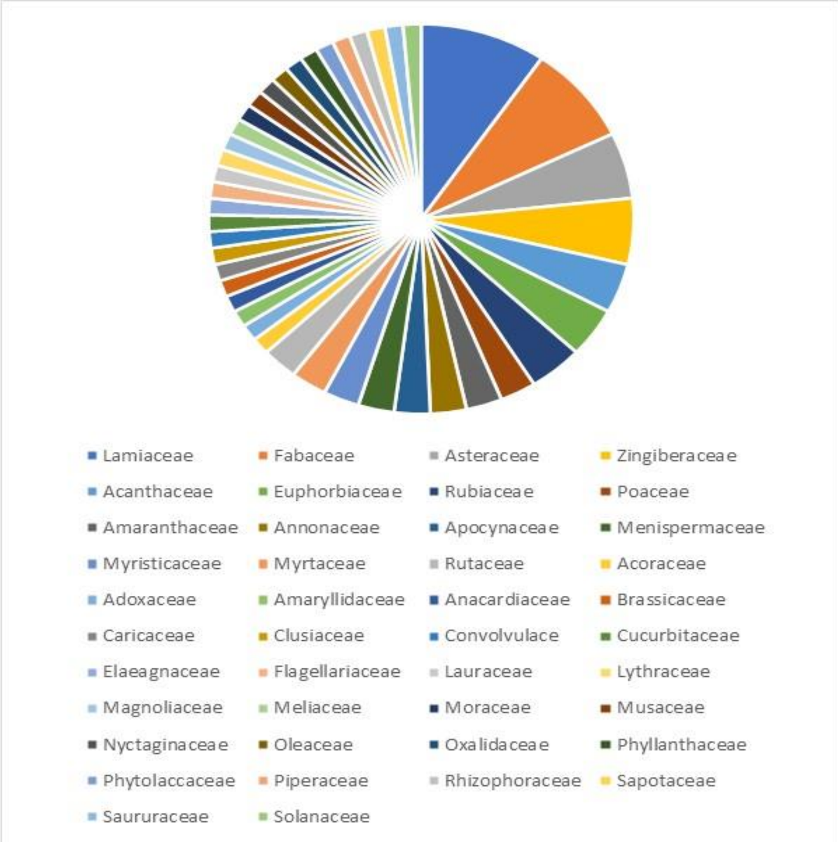

Figure 1. Family-wise distribution of medicinal plants in Pie graph.

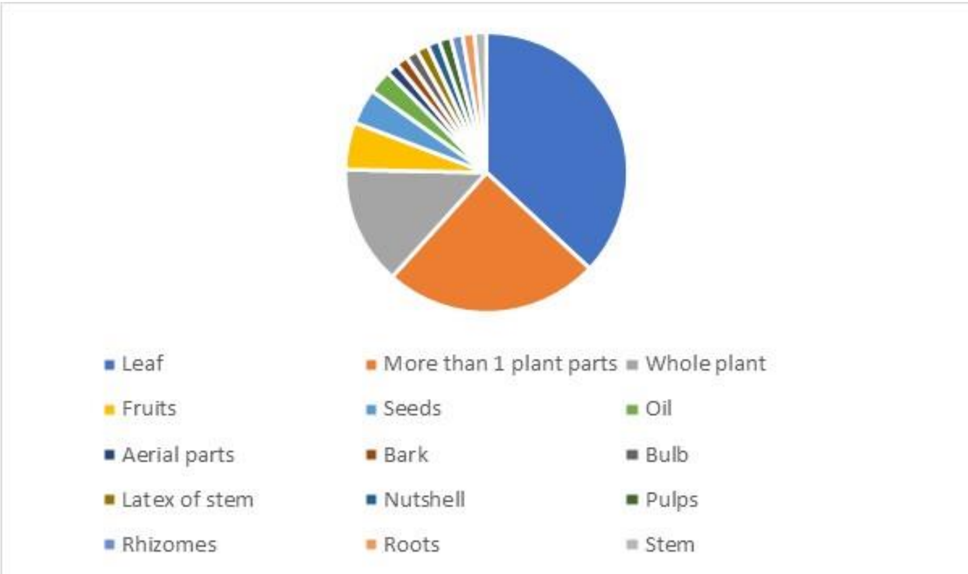

Figure 2. Plant parts use of medicinal plants in Pie graph.

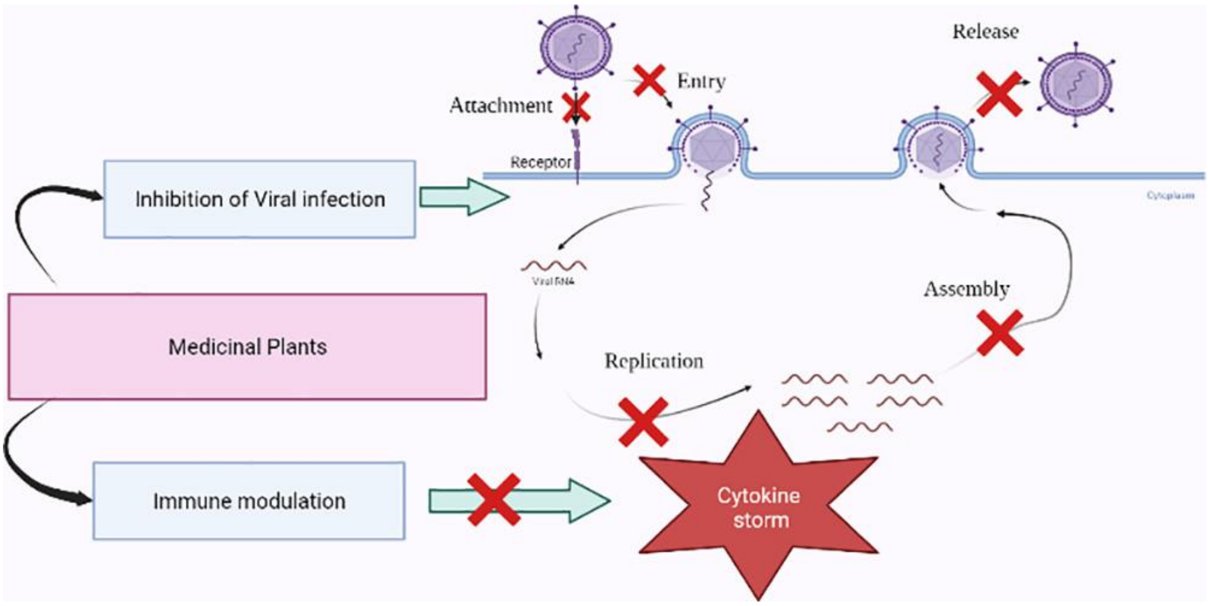

Figure 3. Illustration of dengue virus inhibition mechanisms by medicinal plants (adopted from Altamish *et al*., 2022).

Table 1: List of the medicinal plants used against dengue.

Sl. No.	Bangla/Common Name	Scientific name	Family	Part used	Active constituents	Reference
1.	Kalmegh	*Andrographis paniculata* (Burm.f.) Wall. *ex* Nees*	Acanthaceae	Whole plant	Diterpneoid, Andrographolides	Divyaa *et al.*, 2020
2.	Sabah Snake Grass	*Clinacanthus nutans* (Burm.f.) Lindau	Acanthaceae	Leaves, Whole plant	-	Julsrigival *et al.*, 2021
3.	Bashak	*Justicia adhatoda* L.	Acanthaceae	Arial parts	-	Wilson *et al.*, 2021
4.	Botch	*Acorus calamus* L.*	Acoraceae	Leaves, Roots	β-asarone. Acoric acid, Calamusin D	Rosmalena *et al.*, 2019
5.	Elder	*Sambucus nigra* L.	Adoxaceae	Flower, Leaves	Alkaloids, Flavonoids, Coumarins	Julsrigival *et al.*, 2021
6.	Malancha	*Alternanthera philoxeroides* (Mart.) Griseb.	Amaranthaceae	Whole plant	Flavonoids, Saponins	Altamish *et al.*, 2022
7.	Shalinche/Carpet Weed	*Alternanthera sessilis* (L.) DC.	Amaranthaceae	Leaves	-	Saleh and Kamisah, 2021
8.	Garlic	*Allium sativum* L.	Amaryllidaceae	Bulb	Diallyl disulfide (DADS)	Altamish *et al.*, 2022
9.	Cheshunt	*Anacardium occidentale* L.	Anacardiaceae	Nutshell	Cardol Triene	Loaiza-Cano *et al.*, 2021
10.	Atta/Custard apple	*Annona reticulata* L.	Annonaceae	Bark, Fruit	-	Saleh and Kamisah, 2021
11.	Soursop	*Annona muricata* L.	Annonaceae	Fruit	-	Saleh and Kamisah, 2021
12.	Chatim	*Alstonia scholaris* (L.) R.Br.	Apocynaceae	Leaves	Alstotides	Julsrigival *et al.*, 2021
13.	Nayantara	*Catharanthus roseus*(L.) G.Don	Apocynaceae	Whole plant, Leaves	-	Islam *et al.*, 2014
14.	Assamlata	*Mikania cordata* (Burm.f.) B.L.Rob.	Asteraceae	Leaves	-	Rahmatullah *et al.*, 2009
15.	Bikashlata/Bittervine	*Mikania micrantha* Kunth	Asteraceae	Leaves	-	Bradacs *et al.*, 2011
16.	Tridhara	*Tridax procumbers* L.	Asteraceae	Stem	Flavonoids	Bhuiyan *et al.*, 2020
17.	Cucushim	*Vernonia cinereal* (L.) H.Rob	Asteraceae	Leaves	Phenolics (gallic acid)	Bhuiyan *et al.*, 2020
18.	Field Mustard	*Brassica campestris* L.	Brassicaceae	Oil	-	Saleh and Kamisah, 2021
19.	Papaya	*Carica papaya* L.	Caricaceae	Leaves, Fruits	Quercetin	Sarker *et al.*, 2021
20.	Mangosteen	*Garcinia mangostana* L.	Clusiaceae	Fruit pericarp	α-mangostin	Altamish *et al.*, 2022
21.	Sweet potato	*Ipomoea batatas* (L.) Lam.	Convolvulaceae	Leaves		Saleh and Kamisah, 2021
22.	Bitter gourd	*Momordica charantia* L.	Cucurbitaceae	Roots, Fruits	Potent protein	Desai *et al.*, 2020
23.	Seaberry	*Hippophae rhamnoides* L.	Elaeagnaceae	Leaves	-	Divyaa *et al.*, 2020
24.	Bishkatali	*Cladogynos orientalis* Zipp. *ex* Span.	Euphorbiaceae	Whole plant	-	Klawikkan *et al.*, 2011
25.	Dudhia/Asthma-plant	*Euphorbia hirta* L.	Euphorbiaceae	Leaves, stems. roots	-	Fiscal, 2017
26.	Multigreen	*Breynia androgyna* (L.) Chakrab. & N.P.Balakr.	Euphorbiaceae	Leaves	β-sitosterol	Joshi *et al.*, 2023
27.	Black Bean	*Castanospermum australe* A.Cunn. *ex* Mudie	Fabaceae	Seeds	Castanospermine	Altamish *et al.*, 2022
28.	Licorice	*Glycyrrhiza glabra* L.	Fabaceae	Root	Glycyrrhizin	Babbar *et al.*, 2023
29.	Ipil Ipil	*Leucaena leucocephala* (Lam.) de Wit	Fabaceae	Seeds	Galactomannan	Altamish *et al.*, 2022
30.	Khair	*Senegalia catechu* (L.f.) P.J.H.Hurter & Mabb.	Fabaceae		Pep-RTYM, Catechin, Quercetin	Altamish *et al.*, 2022
31.	Sonalata	*Senna alexandrina* Mill.	Fabaceae	Leaves	Phenolic glycosides	Dhiman *et al.*, 2022
32.	Methi/Fenugreek	*Trigonella foenam-graecum* L.	Fabaceae	Leaves	-	Deep *et al.*, 2018
33.	Bon Chad	*Flagellaria indica* L.	Flagellariaceae	Whole plant	-	Klawikkan *et al.*, 2011
34.	Musk Basil	*Basilicum polystachyon* (L.) Moench	Lamiaceae	Whole plant	-	Altamish *et al.*, 2022
35.	Bhat/Glory bower	*Clerodendrum viscosum* L.	Lamiaceae	Leaves	-	Rahmatullah *et al.*, 2011
36.	Patabahar/Coleus	*Coleus scutellarioides* (L.) Benth.	Lamiaceae	Leaves	-	Gascon, 2011
37.	Wild Pudina/Wild mint	*Mentha arvensis* L.*	Lamiaceae	Leaves	-	Gascon, 2011
38.	Tulsi/Holy Basil	*Ocimum tenuiflorum* L.	Lamiaceae	Leaves	-	Chand *et al.*, 2018
39.	Java Tea	*Orthosiphon aristatus* (Blume) Miq. var. *aristatus*	Lamiaceae	Leaves		Saleh and Kamisah, 2021
40.	Nishinda	*Vitex negundo* L.	Lamiaceae	Leaves	-	Gascon, 2011

41.	Avocado	*Persea americana* Mill.	Lauraceae	Fruits	(2 *R*,4 *R*)-1,2,4-trihydroxyheptadec-16-yne (THHY)	Altamish *et al.*, 2022
42.	Dalim/Pomegranate	*Punica granatum* L.	Lythraceae	Fruits	Punicalagin	Loaiza-Cano *et al.*, 2021
43.	Magnolia	*Magnolia officinalis* Rehder & Wilson	Magnoliaceae	Bark, Seed cones	Honokiol (Lignan Biphenol)	Fang *et al.*, 2015
44.	Neem	*Azadirachta indica* A.Juss.*	Meliaceae	Leaves	Azadirachtin	Parida *et al.*, 2002
45.	Velvet leaf	*Cissampelos pareira* L.	Menispermaceae	Aerial parts	Cissampelo flavone	Babbar *et al*., 2023
46.	Gulancha/Heart-leaved moonseed	*Tinospora cordifolia* (Willd.) Hook.f. &Thomson	Menispermaceae	Leaves, Stems	Alkaloids, Glycosides, Steroids, Flavonoids	Deep *et al.*, 2018
47.	Hauili	*Ficus septica* Burm.f.	Moraceae	Leaves, Stem, Fruit, Heartwood	Alkaloids, Lignans, Triterpenes, Flavonoids, And Steroids	Altamish *et al.*, 2022
48.	Banana	*Musa* × *paradisiaca* L.	Musaceae	Latex of stems	-	Saleh and Kamisah, 2021
49.	Nutmeg	*Myristica fatua* Houtt.	Myristicaceae	Seeds	Artesunic acid, Homoegonol, Myristicin	Rosmalena *et al.*, 2019
50.	Nutmeg	*Myristica fragrans* Houtt.	Myristicaceae	Leaves	-	Saleh and Kamisah, 2021
51.	Guava	*Psidium guajava* L.*	Myrtaceae	Leaves, Bark, Young fruits	-	Deep *et al.*, 2018; Batoro & Siswanto, 2017
52.	Jamrul	*Syzygium samarangense* (Blume) Merr. & L.M.Perry	Myrtaceae	Leaves	5-hydroxy- 7- methoxy- 6-methylfla vanone (FN5Y)	Altamish *et al*., 2022
53.	Punarnava Red	*Boerhavia diffusa* L.	Nyctaginaceae	Leaves, Stem	tannins, phenols, Flavonoids, Others	Babbar *et al*., 2023
54.	Sheuli, Shefali	*Nyctanthes arbor-tristis* L.	Oleaceae	Leaves	β-Sitosterol, Calceolarioside A	Morshed *et al*., 2022
55.	Kamranga/Carambola	*Averrhoa carambola* L.	Oxalidaceae	Leaves, Barks, Fruit	2-dodecyl-6-methoxycyclohexa -2,5-diene-1,4-dione	Wei *et al*., 2018
56.	Bhui amla	*Phyllanthus amarus* Schumach. & Thonn.	Phyllanthaceae	Whole plant	-	Altamish *et al.*, 2022
57.	Southern pokeweed	*Phytolacca bogotensis* Kunth.	Phytolaccaceae	Fresh leaves	-	Bussmann & Sharon, 2006
58.	Chuijhal	*Piper retrofractum* Vahl.*	Piperaceae	Whole plant	-	Klawikkan *et al.*, 2011
59.	Lemon grass	*Cymbopogon citratus* (DC.) Stapf.*	Poaceae	Oil	Geranial, Geranyl acetate	Rosmalena *et al.*, 2019
60.	Banar-mul	*Vetiveria zizaniodes* L.*	Poaceae	Roots	Khushimol, α-vetiverone, β-vetiverone, ethyl 4-(4- methylphenyl)-4- pentenoate	Firuj *et al*. 2023
61.	Garjan	*Rhizophora apiculata* Blume	Rhizophoraceae	Whole plant	-	Klawikkan *et al.*, 2011
62.	Cinchona	*Cinchona* spp.	Rubiaceae	Bark	-	Sarah *et al.*, 2020
63.	Bishphal	*Pavetta tomentosa* Roxb. *ex* Sm.	Rubiaceae	Leaves	Saponins, Flavonoids and Alkaloids,	Pratheeba *et al.*, 2019
64.	Thankuni	*Tarenna asiatica* (L.) Kuntze *ex* K.Schum.	Rubiaceae	Leaves	Saponins, Favonoids and Alkaloids,	Pratheeba *et al.*, 2019
65.	Lemon	*Citrus limon* (L.) Osbeck*	Rutaceae	Pulps	-	Hajdu & Hohmann, 2011
66.	Euodia	*Euodia species*	Rutaceae	Leaves	-	Kandowangko *et al.*, 2011
67.	Miracle fruit	*Synespalum dulcificum* (Schumach. & Thonn.) Daniell.	Sapotaceae	Leaves	-	Gascon, 2011
68.	Aishta nagini	*Houttuynia cordata* Thumb.	Saururaceae	Whole plant	Chlorogenic acid	Klawikkan *et al.*, 2011
69.	Bon tepari	*Physalis angulata* L.	Solanaceae	Leaves	-	Bradacs *et al.*, 2011
70.	Chinese Ada/Fingerroot	*Boesenbergia rotunda* (L.) Mansf.	Zingiberaceae	Rhizomes	Cardamonin	Kiat *et al*., 2006
71.	Holud/Curcuma	*Curcuma longa* L.*	Zingiberaceae	Rhizomes, Leaves	Curcumin	Ichsyani *et al.*, 2017
72.	Ada/Ginger	*Zingiber officinale* L.*	Zingiberaceae	Rhizomes, Leaves	-	Sharma *et al.*, 2015
73.	Bon Ada/Ginger	*Zingiber purpureum* Rosc.	Zingiberaceae	Rhizomes, Leaves	-	Kandowangko *et al.*, 2011

* Plants with insecticidal properties