



Biological Activities of *Adenium obesum* (Forssk.) Roem. & Schult.: A Concise Review

Dipak Paul, Karabi Biswas, Sankar Narayan Sinha*

Department of Botany, University of Kalyani, Kalyani 741235, West Bengal, India.

*For correspondence: sinhasn62@yahoo.co.in

Article Info: Received 24 Nov 2015; Revised: 28 Dec 2015; Accepted 29 Dec 2015.

ABSTRACT

Adenium obesum (Forssk.) Roem. and Schult. is a succulent shrub commonly known as desert rose belongs to the family Apocynaceae. *Adenium obesum* is a native of Africa but nowadays is cultivated in several parts of the world including India as a popular ornamental plant. This plant represents one of the richest sources of phytochemicals such as glycosides and posses great potential for pharmaceutical and piscicultural applications. This review is therefore, an effort to give a detailed study of the literature on biological activities of *Adenium obesum*. It shows remarkable anticancer, antiviral, antibacterial, trypanocidal, acaricidal, molluscicidal, antioxidant and piscicidal activities. This review concludes that *Adenium obesum* has a great potential to treat various diseases, and could be used as a source for novel healthcare products in the near future, which requires further experimentation.

Keywords: *Adenium obesum*, Biological activities, Anticancer activity, Antibacterial activity

1. INTRODUCTION

Since time immemorial plants have been used as source of medicine. For thousands of years native peoples throughout the world have used traditional herbal medicine to treat many infectious human diseases [1]. Natural products and herbal medicines are a good source of new therapeutic agents and for the development of complementary and alternative medicines over traditional drug regimens [2]. In the last few years, there has been an exponential development in the field of herbal medicine, and these phytomedicines are gradually gaining popularity both in developed and developing countries due to their origin in nature, more potent intreatment of health problems and less side effects as

compared to marketed drugs [3-5]. Over half of the population of world depend on traditional medicine for healthcare, more than 80% of the less developed countries [6-8]. Medicinal plants are widely used by all sections of the human society either directly as medicines of folkloric value or indirectly as pharmaceutical formulation in modern medicine [9]. Between 10000 and 53000 species of plant are utilized in traditional medicine, and use of plants in medicine is an important and ubiquitous cultural trait [10,11]. The use of various parts of different medicinal plants to heal particular diseases has been in vogue from ancient times. Several diverse secondary metabolites are produced by plants that are not required for the immediate survival of the plant

but are synthesized in response to stress as a measure of protection from microorganisms, diseases or from the environment [12]. A good number of secondary metabolites from plants possess significant biological activities with various applications [13]. These medicinal plants are usually known to exert their considerable diverse health benefits through the diverse phytochemicals they contain [14-19].

Adenium obesum (Forssk.) Roem. & Schult., a succulent plant commonly known as desert rose belongs to the dogbane family Apocynaceae is native from Africa such as Ethiopia, Kenya, Senegal, Somalia, Sudan and Tanzania, also found in Oman, Saudi Arabia and Yemen as wild plant [20-23]. It is one of the popular ornamental plants cultivated in many humid, tropical countries for decades such as India, Philippines and Thailand, with great relevance in the ornamental market due to its wide range of flower colour among cultivars, beautiful sculptural caudex and tolerance to drought stress [24-27]. The present review is a research update on *Adenium obesum*, an attractive shrub with significant medicinal attributes with an in-depth study of its biological activities.

2. PLANT DESCRIPTION

Adenium obesum is a beautiful deciduous pachycaul shrub with an attractive swollen trunk and fleshy, smooth, greyish-green to brown coloured, irregular-spaced branches that make it a unique and attractive for bonsai. Leaves are simple, spirally arranged at the ends of the branches and it produces lovely, variously coloured star-shaped flowers, but without fragrance. Terminal clusters of flowers are formed during the entire year. During summer the plant may be almost totally covered in blooms [25] (Fig. 1). Fruit is follicle and at maturity it splits along one side to release seeds with hairy pappus attached for dispersion by the wind [25].



Figure 1. Different parts of *Adenium obesum*.
A. Flowers, B. Stem, C. Leaves

3. SYSTEMATIC POSITION

The systematic position of *Adenium obesum* is demonstrated as follows:

Kingdom: Plantae
Subkingdom: Tracheobionta
Superdivision: Spermatophyta
Division: Magnoliophyta
Class: Magnoliopsida
Subclass: Asteridae
Order: Gentianales
Family: Apocynaceae
Genus: *Adenium* Roem. & Schult.
Species: *Adenium obesum* (Forssk.)
Roem. & Schult.

4. BIOLOGICAL ACTIVITIES

Adenium obesum is an important medicinal plant which shows a wide range of biological activities (Fig. 2). The plant exhibits anticancer, antiviral, antibacterial, trypanocidal, acaricidal, molluscicidal, antioxidant and piscicidal activities which are presented below.

4.1. Anticancer Activity

After several years of intensive research, various bioactive molecules from *Adenium obesum* were identified to prevent and treat the cancer disease. Ethanol extract of aerial part of *A. obesum* exhibited cytotoxic property against epidermoid carcinoma of the nasopharynx test system of human beings. The bioactive molecules in the extract were identified as the hongheloside A, honghelin, cardenolides somalin, and, 16-acetylstrospeside, and the flavonol 3,3'-bis(*O*-methyl)quercetin [28]. Yamauchi and Abe [29] isolated 30 cardiac glycosides and pregnanes from the roots and the stems of *A. obesum*. Oleandrigenin β -gentiobiosyl- β -thevetoside was the major glycoside and neridienone A and 16, 17-dihydroneidienone A, common pregnanes in *A. obesum*, were isolated. Cepleanu *et al* [30] reported that the crude extracts of *A. obesum* exhibited very strong cytotoxicity against two human colon carcinoma cell lines. Two pregnanes possessing cytotoxic property against murine leukemia P388/S cells were isolated from the leaves of *A. obesum* [31]. Arai *et al* [32] isolated 17 cardiac glycosides from bioassay-guided fractionation of this plant extract. These compounds showed strong hedgehog Hh/GLI signalling inhibitory activities. The inhibition of GLI-

related protein expression was also observed in pancreatic cancer cells (PANC1) of human that express Hh/GLI components erroneously. The expressions of GLI-related proteins PTCH and BCL2 were inhibited. Further these active compounds also exhibited selective cytotoxicity against two cancer cell lines. Almedhar *et al* [33] reported that the methanolic extracts of *A. obesum* exhibited potential cytotoxic activity against three human cancer cell lines, such as, breast cancer (MCF7), cervix cancer (HELA) and hepatocellular carcinoma (HEPG2) cells.

4.2. Antiviral Activity

Methanolic extracts of *Adenium obesum* exhibited *in vitro* anti-influenza virus activity using influenza virus A/PR/8/34 (H1N1). The isolated active compound was identified as oleandrogenin- β -D-glucosyl (1 \rightarrow 4)- β -D-digitalose [34].

4.3. Antibacterial Activity

The antibacterial activities of *Adenium obesum* have been proved against several bacterial strains (Table 1). Adamu *et al* [35] reported that the aqueous extract of stem bark of *A. obesum* have possess strong antibacterial potential against different hospital borne pathogenic bacterial strains, namely, *Proteus mirabilis*, *Pseudomonas aeruginosa*, *Staphylococcus aureus* and *Escherichia coli*. Methanolic and petroleum ether extracts of the stem-bark of *A. obesum* also exhibited potent antibacterial property against several pathogenic Gram negative bacteria strains, namely, *Escherichia coli*, *Neisseria gonorrhoea* and *Salmonella typhi* [36]. According to Tijjani *et al* [37] methanolic extract of *A. obesum* stem-bark in combination with oxytetracycline indicated strong antibacterial activity against the pathogenic bacterial isolates. Hossain *et al* [38] evaluated antimicrobial potency of different solvent extract of *A. obesum* stem against food-borne pathogenic bacterial strains in Oman. According to them the average range of inhibition potency crude extracts with different polarities was 0-24% by maceration method and inhibition potency 0-17% by soxhlet method. Hossain *et al* [39] reported that different crude extracts of the leaves of *A. obesum* have also possessed strong antibacterial activities against different pathogenic bacterial strains. Sharma *et al* [40] showed that methanolic extract of *A. obesum* leaves has potent antibacterial activity against Gram positive bacteria *Staphylococcus*

aureus and *Bacillus amyloliquefaciens* and, ineffective against Gram negative bacteria *Pseudomonas aeruginosa* and *Escherichia coli*. Their study suggested that leaves of *A. obesum* plant can be exploited as an antibacterial agent which may be utilized as potent therapeutic agents for various infectious diseases.

4.4. Antioxidant Activity

Bungihan and Matias [41] reported considerable radical scavenging activities of ethanolic extract of *Adenium obesum* flower using DPPH assay from Nueva Vizcaya, Philippines. Ebrahim *et al* [42] also reported that *Adenium obesum* flower extracts are rich source of anthocyanins and possess a significant antioxidant activity. Alseini [43] reported high antioxidant activity of methanolic extract *Adenium obesum* flower in Saudi Arabia. In another work, antioxidant activity of methanolic extract of *A. obesum* stem was evaluating using DPPH assay and showed that different concentration and different crude extracts from the stems of *A. obesum* exhibited strong free radical scavenging activity. The strong free radical scavenging activity in different stems crude extracts might be due to high quantity of poly phenolic compounds [44]. According to AL-Ghudani and Hossain [45] different crude extracts of roots of *Adenium obesum* exhibited significant antioxidant activity by DPPH and maceration methods.

4.5. Trypanocidal Activity

Methanol extract of *Adenium obesum* stem bark exhibited significant trypanocidal activity against *Trypanosoma brucei*. Using a 1 h exposure time, methanol extracts of *A. obesum* stem bark stopped 50% of the motility of *T. brucei in vitro* at 4 mg/mL [46].

4.6. Larvicidal Activity

Dichloromethane extract of *Adenium obesum* tuber showed promising larvicidal activity against *Aedes aegypti* mosquito larvae, vector of yellow fever, dengue hemorrhagic fever diseases [30].

4.7. Acaricidal Activity

Aqueous stem bark extract of *Adenium obesum* showed effective acaricidal activity against the ticks *Boophilus* and *Amblyomma* [47].



Figure 2. Various biological activities of *Adenium obesum*

Table 1. Antibacterial activity of different extracts of *Adenium obesum*

Parts of <i>Adenium obesum</i> used	Solvent used for extraction	Bacteria tested	References
Stem bark	Aqueous	<i>Escherichia coli</i> , <i>Proteus mirabilis</i> , <i>Pseudomonas aeruginosa</i> , <i>Staphylococcus aureus</i>	[35]
Stem bark	Methanol, Petroleum ether	<i>Escherichia coli</i> , <i>Klebsiella pneumoniae</i> , <i>Neisseria gonorrhoea</i> , <i>Pseudomonas aeruginosa</i> , <i>Salmonella typhi</i>	[36]
Stem bark	Methanol	<i>Bacillus subtilis</i> , <i>Corynebacterium ulcerans</i> , <i>Escherichia coli</i> , <i>Klebsiella pneumoniae</i> , <i>Pseudomonas aeruginosa</i> , <i>Salmonella typhi</i> , <i>Staphylococcus aureus</i> , <i>Streptococcus pyogenes</i>	[37]
Stem	Methanol	<i>Escherichia coli</i> , <i>Proteus vulgaris</i> , <i>Pseudomonas aeruginosa</i> , <i>Staphylococcus aureus</i>	[38]
Leaves	Methanol	<i>Escherichia coli</i> , <i>Proteus vulgaris</i> , <i>Pseudomonas aeruginosa</i> , <i>Staphylococcus aureus</i>	[39]
Leaves	Aqueous, Methanol	<i>Bacillus amyloliquefaciens</i> , <i>Escherichia coli</i> , <i>Pseudomonas aeruginosa</i> , <i>Staphylococcus aureus</i>	[40]

4.8. Molluscicidal Activity

Methanol extracts of *Adenium obesum* at sublethal concentration may be used to control the snail *Bulinus truncatus* as it inhibits biochemistry and physiology of the snail [48].

4.9. Piscicidal Activity

Adenium obesum is a known piscicidal plant [49]. The plant extract can be exploited for effective management of aquaculture pond against some undesirable weed predatory aquatic organisms in order to help safeguard native species and/or the stocked desired fish species [50]. The ethanol extract of *Adenium obesum* stem bark is very toxic which can be used as a tool for management of aquaculture pond before stocking of desired fish species was evaluated in *Clarias gariepinus* by Abalaka *et al* [51]. Abalaka *et al* [52] also reported that the plant extract treated fish exhibited signs of behavioural changes with respiratory distress, adaptive responses and nervous compromise as well as mortality in some of the extract treated fish.

5. CONCLUSION

In the present investigation, relevant literatures have been reviewed to congregate the information about biological activities of *Adenium obesum*. On the basis of the information given in the present review, it could be concluded that *Adenium obesum* is a very important and interesting medicinal plant with an enormous potential as anticancer, antibacterial, antiviral and other therapeutic agents and as a vast source of phytochemicals showing antioxidant activities. The biological activities showed by this plant suggest the development of therapeutic medicinal products for human uses. The therapeutic potential of the plant is yet to be exploited and more researches are required to upgrade the extraction and phytochemical analyses processes.

Conflict of Interest

The authors declare that they have no conflicts of interest.

References

1. Fabricant DS and Farnsworth NR (2001). The value of plants used in traditional medicine for drug discovery. *Environmental Health Perspectives*; 109:69-75.

2. Cordell GA and Colvard MD (2012). Natural products and traditional medicine: turning on a paradigm. *Journal of Natural Products*; 75(3):514-525.
3. Smith CM and Reynard AM (1995). *Essentials of pharmacology*, WB Saunders, Philadelphia, PA, USA.
4. Chaudhary MI, Qing H, Xiao PG and Cheng YY (2007). *Clematis huchouensis* Tamura: a traditional Chinese herbal medicine and its quality control using a high performance liquid chromatography technique. *Biological and Pharmaceutical Bulletin*; 30(1):165-168.
5. Agarwal P, Fatima A and Singh PP (2012). Herbal medicine scenario in India and European countries. *Journal of Pharmacognosy & Phytochemistry*; 1(4):88-93.
6. Farnsworth NR, Akerele O, Bingel AS, Soejarto DD and Guo Z (1985). Medicinal plants in therapy. *Bulletin of the World Health Organization*; 63(6):965-981.
7. FAO (2004). Trade in medicinal plants, Economic and Social Department, Food, and Agriculture Organization of the United Nations, Rome, 2-3.
8. Nabi NG and Shrivastava M (2015). *In vitro* propagation of *Psoralea corylifolia* L.-an important endangered medicinal plant. *Indian Journal of Applied and Pure Biology*; 30(2):201-205.
9. Uniyal B (2003). Utilization of medicinal plants by the rural women of Kulu, Himachal Pradesh. *Indian Journal of Traditional Knowledge*; 2(4):366-370.
10. McChesney JD, Venkataraman SK and Henri JT (2007). Plant natural products: back to the future or into extinction? *Phytochemistry*; 68(14):2015-2022.
11. Saslis-Lagoudakis CH, Hawkins JA, Greenhill SJ, Pendry CA, Watson MF, Tuladhar-Douglas W, Baral SR and Savolainen V (2014). The evolution of traditional knowledge: environment shapes medicinal plant use in Nepal. *Proceedings of the Royal Society of London B: Biological Sciences*; 281(1780):20132768.
12. Goossens A, Häkkinen ST, Laakso I, Seppänen-Laakso T, Biondi S, De Sutter V, Lammertyn F, Nuutila AM, Söderlund H, Zabeau M, Inzé D and Oksman-Caldentey KM (2003). A functional genomics approach toward the understanding of secondary

- metabolism in plant cells. *Proceedings of the National Academy of Sciences*; 100 (14):8595-8600.
13. Birari RB and Bhutani KK (2007). Pancreatic lipase inhibitors from natural sources: unexplored potential. *Drug Discovery Today*; 12(19):879-889.
 14. Sarikurku C, Eryigit F, Cengiz M, Tepe B, Cakir A and Mete E (2012). Screening of the antioxidant activity of the essential oil and methanol extract of *Mentha pulegium* L. from Turkey. *Spectrosc Letters*; 45(5):352-358.
 15. Alzoubi HM, Ibrahim AI, Alsbou MS and Aqel AA (2014). Inhibitory effect of Mediterranean sage and rosemary on clinical and community isolates of methicillin-resistant *Staphylococcus aureus*. *Jordan Journal of Biological Sciences*; 7(3):161-164.
 16. Sinha SN and Paul D (2014). Antioxidant potentials of *Parthenium hysterophorus* L leaf extracts. *Scientific Research Journal of India*; 3(2):80-86.
 17. Dharajiya D, Khatrani T, Patel P and Moitra N (2015). Evaluation of antifungal activity of *Embllica officinalis*, *Aloe vera* and *Vitex negundo* extracts. *Journal of Chemical, Biological and Physical Sciences*; 5(4):3990-3996.
 18. Dhinek A and Sowmia C (2015). Phytochemical analysis and free radical scavenging potential of *Riccinus communis* based polyherbal formulation. *Malaya Journal of Biosciences*; 2(2):96-103
 19. Kaewsuan S, Yuenyongsawad S, Plubrukarn A, Kaewchoothong A, Raksawong A, Puttarak P and Apirug C (2015). Bioactive interruptins A and B from *Cyclosorus terminans*: antibacterial, anticancer, stem cell proliferation and ROS scavenging activities. *Songklanakarin Journal of Science and Technology*; 37(3):309-317.
 20. Dimmit M and Hanson C (1991). The genus *Adenium* in cultivation. Part 1: *A. obesum* and *A. multiflorum*. *Cactus and Succulent Journal*; 63(5):223-225.
 21. Arbonnier M (2004). Trees, shrubs and lianas of West African dry zones, Margraf Publishers, CIRAD, MNHN, Paris.
 22. Oyen LPA (2008). *Adenium obesum* (Forssk.) Roem. & Schult. In Schmelzer GH and Gurib-Fakim A (Eds.), Plant resources of tropical Africa 11(1): Medicinal plants 1. Backhuys Publishers, Wageningen, Netherlands, pp. 46-49.
 23. Win NKK, Back CG, Kim YH and Jung HY (2012). Desert rose witches' broom disease associated with '*Candidatus Phytoplasma aurantifolia*'. *Journal of General Plant Pathology*; 78(1):73-76.
 24. Rowley GD (1987). Caudice form and Pachycaul succulents, Strawberry Press, Mill Valley, CA.
 25. McLaughlin J and Garofalo J (2002). The desert rose (*Adenium obesum*). Miami-Dade: Miami-Dade County/University of Florida Cooperative Extension Service, pp. 66.
 26. Kanchanapoom K, Sunheem S and Kanchanapoom K (2010). *In vitro* propagation of *Adenium obesum* (Forssk.) Roem. and Schult. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca*; 38(3):209-213.
 27. McBride KM, Henny RJ, Mellich TA and Chen J (2014). Mineral nutrition of *Adenium obesum* 'red'. *HortScience*; 49(12):1518-1522.
 28. Hoffmann JJ and Cole JR (1977). Phytochemical investigation of *Adenium obesum* Forskal (Apocynaceae): isolation and identification of cytotoxic agents. *Journal of Pharmaceutical Sciences*; 66(9):1336-1338.
 29. Yamauchi T and Abe F (1990). Cardiac glycosides and pregnanes from *Adenium obesum* (studies on the constituents of *Adenium*. I). *Chemical and Pharmaceutical Bulletin*; 38(3):669-672.
 30. Cepleanu F, Hamburger MO, Sordat B, Msonthi JD, Gupta MP, Saadou M and Hostettmann K (1994). Screening of tropical medicinal plants for molluscicidal, larvicidal, fungicidal and cytotoxic activities and brine shrimp toxicity. *International Journal of Pharmacognosy*; 32(3):294-307.
 31. Nakamura M, Ishibashi M, Okuyama E, Koyano T, Kowithayakorn T, Hayashi M and Komiyama K (2000). Cytotoxic pregnanes from leaves of *Adenium obesum*. *Natural Medicines*; 54(3):158-159.
 32. Arai MA, Tateno C, Koyano T, Kowithayakorn T, Kawabe S and Ishibashi M (2011). New hedgehog/GLI-signaling inhibitors from *Adenium obesum*. *Organic and Biomolecular Chemistry*; 9(4):1133-1139.

33. Almehdar H, Abdallah HM, Osman AMM and Abdel-Sattar EA (2012). *In vitro* cytotoxic screening of selected Saudi medicinal plants. *Journal of Natural Medicines*; 66(2):406-412.
34. Kiyohara H, Ichino C, Kawamura Y, Nagai T, Sato N, Yamada H, Salama MM and Abdel-Sattar E (2012). *In vitro* anti-influenza virus activity of a cardiotonic glycoside from *Adenium obesum* (Forssk.). *Phytomedicine*; 19(2):111-114.
35. Adamu HM, Abayeh OJ, Agho MO, Abdullahi AL, Uba A, Dukku HU and Wufem BM (2005). An ethnobotanical survey of Bauchi State herbal plants and their antimicrobial activity. *Journal of Ethnopharmacology*; 99(1):1-4.
36. Tijjani A, Ndukwe IG and Ayo RG (2011). Studies on antibacterial activity of *Adenium obesum* (Apocynaceae) stem - bark. *Continental Journal of Microbiology*; 5(1):12-17.
37. Tijjani A, Sallau MS and Sunus I (2011). Synergistic activity of methanolic extract of *Adenium obesum* (Apocynaceae) stem-bark and oxytetracycline against some clinical bacterial isolates. *Bayero Journal of Pure and Applied Sciences*; 4(1):79-82.
38. Hossain MA, Al-Abri THA, Al-Musalami AHS, Akhtar MS and Said S (2014). Evaluation of different extraction methods on antimicrobial potency of *Adenium obesum* stem against food borne pathogenic bacterial strains in Oman. *Asian Pacific Journal of Tropical Disease*; 4:S985-S989.
39. Hossain MA, Al-Musalami AHS, Akhtar MS and Said S (2014). A comparison of the antimicrobial effectiveness of different polarities crude extracts from the leaves of *Adenium obesum* used in Omani traditional medicine for the treatment of microbial infections. *Asian Pacific Journal of Tropical Disease*; 4:S934-S937.
40. Sharma Y, Nagar A and Shukla S (2015). Antimicrobial activity and phytochemical screening of *Adenium obesum* (desert rose) leaf. *International Journal of Pharma and Bio Sciences*; 6(3):85-92.
41. Bungihan ME and Matias CA (2013). Determination of the antioxidant, phytochemical and antibacterial profiles of flowers from selected ornamental plants in Nueva Vizcaya, Philippines. *Journal of Agricultural Science and Technology B*; 3:833-841.
42. Ebrahim N, Kershi RM and Rastrelli L (2013). Free radical scavenging activity and anthocyanin in flower of *Adenium obesum* collected from Yemen. *Journal of Pharmacy and Phytotherapeutics*; 1:5-7.
43. Alseini AII (2014). Total phenolic, total flavonoid contents and radical scavenging activities of 10 Arabian herbs and spices. *Unique Journal of Pharmaceutical and Biological Sciences*; 2(3):5-11.
44. Hossain MA, Alabri THA, Al-Musalami AHS, Akhtar MS and Said S (2014). Evaluation of *in vitro* antioxidant potential of different polarities stem crude extracts by different extraction methods of *Adenium obesum*. *Journal of Coastal Life Medicine*; 2(9):699-703.
45. AL-Ghudani MKN and Hossain MA (2015). Determination of total phenolics, flavonoids and antioxidant activity of root crude extracts of *Adenium obesum* traditionally used for the treatment of bone dislocations and rheumatism. *Asian Pacific Journal of Tropical Disease*; 5:S155-S158.
46. Atawodi SE (2005). Comparative *in vitro* trypanocidal activities of petroleum ether, chloroform, methanol and aqueous extracts of some Nigerian savannah plants. *African Journal of Biotechnology*; 4(2):177-182.
47. Mgbojikwe LO and Okoye ZSC (2001). Acaricidal efficacy of aqueous stem bark extract of *Adenium obesum* on various life stages of cattle ticks. *Nigerian Journal of Experimental and Applied Biology*; 2:39-43.
48. Bakry FA, Mohamed RT and Hasheesh WS (2011). Impact of methanol extract of *Adenium obesum* plant on some biochemical and biological parameters of *Bulinus truncatus* snails. *Journal of Evolutionary Biology Research*; 3:87-94.
49. Abalaka SE, Fatihu MY, Ibrahim NDG and Ambali SF (2013). Exploitation of ethanol extract of *Adenium obesum* stem bark as a potent organic piscicide. *Research Journal of Biological Sciences*; 8(5):143-149.
50. Abalaka SE, Fatihu MY, Ibrahim NDG and Ambali SF (2015). Gills and skin histopathological evaluation in African sharptooth catfish, *Clarias gariepinus* exposed to ethanol extract of *Adenium obesum* stem bark. *The Egyptian Journal of Aquatic Research*; 41(1):119-127.

51. Abalaka SE, Fatihu MY, Ibrahim NDG and Ambali SF (2015). Liver histopathological changes in *Clarias gariepinus* exposed to ethanol extract of *Adenium obesum* stem bark. *Journal of Morphological Science*; 32(1):22-28.
52. Abalaka SE, Fatihu MY, Ibrahim NDG and Ambali SF (2014). Toxicological evaluation of ethanol extract of *Adenium obesum* stem bark in African catfish. *Clarias gariepinus*. *Journal of Applied Sciences and Environmental Management*; 18(1):49-52.