A REVIEW ON SOME ANTIDIABETIC PLANTS OF INDIA

M.K. RAI

Department of Botany, Danielson College, Chhindwara – 480 001, Madhya Pradesh, India

Received: 12 September, 1994  Accepted: 10 October, 1994

ABSTRACT: The control over diabetes mellitus depends upon the availability of insulin. Various efforts have been made in the recent past to control / check it. There is an increasing demand to use the natural antidiabetic agents. The literature pertaining to antidiabetic herbs is scattered. The present article is a conglomeration of available indigenous literature. It gives an additional information of list of antidiabetic plants which have not been discussed by Nagarajan et al\textsuperscript{76} and Handa et al\textsuperscript{45}. It also presents some common plants used in diabetes, and the future of hypoglycaemic herbal drugs.

INTRODUCTION

Etymologically, the term diabetes can be defined as to “pass through”. The word diabetes has been derived from Greek Word (‘dia’ means through; ‘betes’ means pass). More appropriately it has been defined as the secretion of an inordinate quantity of sweet tasting, urine with a peculiar smell, accompanied with great thirst, dryness of skin, extreme debility, and general emaciation. In diabetes, the deficiency of insulin leads into a complex series of reactions which are clinically manifested as hyperglycemia. It is well known that glucose is an important source of energy for the cerebral tissue, and if it is lost owing to diabetes, the function of tissue is affected. Earlier, mithridate was used in diabetes in homeopathy.

EARLIER WORK

The early detection and treatment of diabetes has been mentioned in Sushruta Samhita and Charak Samhita. A review of literature vouchers that many investigators have contributed in the field of herbal medicine in relation to diabetes (Table 1).
Table 1. Plants reported by various workers for the cure of diabetes

| Name of investigator | Year | No. of Plants |
|----------------------|------|---------------|
| Nadkarni             | 1954 | 42            |
| Mukherji             | 1957 | 12            |
| Aiman                | 1970 | 35            |
| Chaudhury and Vohra  | 1970 | 21            |
| Karnick              | 1972 | 16            |
| Israeli              | 1977 | 100           |
| Nagarajan et al      | 1982 | 76            |
| Tomoda et al         | 1987 | 20            |
| Handa et al          | 1988 | 150           |

SOME HYPOGLYCAEMIC PLANTS

A large number of antidiabetic minerals and drugs of plant origin have been described in classical ayurvedic literature and review given by Nagarajan et al.,76 and Handa et al.45. In both the reviews, a detailed account of medicinal herbs used in diabetes has been discussed in detail. The present review incorporate the additional information, and list of medicinal plants not given in reviews mentioned above.

Handa et al45 listed 150 medicinal plants which have been used as a cure for diabetes. However, he could not include *Abras precatorious*, *Adiantum caudatum*, *Aloe vera*, *Andrographis elongate*, *Berginia*, *ligulata*, *Bombax pentandrum*, *Butea monosperma*, *Caesalpinia crist*, *Carica papaya*, *Cassia auriculata*, *Coccidentalis*, *Centratherum tamala*, *Citullus colycynthis*, *Costus speciosus*, *Curcula longa*, *Decalepsia hamiltonii*, *Emblica officinalis*, *Hordeum vulgare*, *Ichnocarpus fruteacena*, *Kikzia ramosissima*, *Mangifera indica*, *Moringa oleifera*, *Ougenia dalbergoides*, *Paspalum scorbiculatum*, *Phyllanthus amarus*, *Rheum emodi*, *syzygium alternifolium*, *Solanum nigrum*, *Strychnos potatorum*, *Swertia chirata*, *Talinum portulacifolium*, *Terminalia arjuna*, *T. chebula*, *Tinospora cordifolia* and *Tribulus terrestris* which has been listed in the present review.

Nagarajan et al.76 proposed a review of 75 medicinal plants. But *Abras orecatorious*, *Berginia ligulata*, *Bombax pentandrum*, *Bougainvillea spectabilis*, *Butea monosperma*, *Caesalpinia crist*, *Carica papaya*, *Cassia occidentalis*, *Centratherum anthelminticum*, *Cinnamomum tamala*, *Citullus colycynthis*, *Costus speciosus*,
Curcuma longa, Decalpia hamiltonii, Dioscorea bulbifera, emblica officinalis, Ichnocarpus frutescens, Inula racemosa, Melia azadirachta, Mangifera indica, Mangifera oleifera, Ougenia dalbergioides, Paspalum scrobiculatum, Phyllanthus amarus, Psidium guava, Pterocarpus santalinus, Rheum emodi, Solanum nigrum, Syzygium alternifolium, Strychnos potatorum, Swertia chirata, Talinum portulacifolium, Terminalia arjuna, T. chebula, Tinospora cordifolia, and Tribulus terrestris which are given in the present review were not included by Nagarajan et al. 76

Table 2 : Medicinal plants used in diabetes

| Plant                                      | Family               |
|--------------------------------------------|----------------------|
| Abrus precatorius L.                       | Fabaceae             |
| Acacia catechu (Linn.f.) Willld.           | Fabaceae             |
| 1. nilotica (L) Del. Sp. indica (Benth) Brenam | Fabaceae             |
| Adiantum caudatum Linn.                    | Polypodiaceae        |
| Aegle marmelos (Linn.) Corr.               | Rutaceae             |
| Aloe vera (L.). Burm. f.                    | Liliaceae            |
| Andragraphis elongate T. and. Nela Vemu    | Acanthaceae          |
| Berginia ligulata (Wall.) Engl.            | Saxifragaceae        |
| Bombax pentaridrum Linn.                   | Bombacaceae          |
| Bougainvillea spectabilis Linn.            | Nyctaginaceae        |
| Butea monosperma (Lamk.) Kuntz            | Fabaceae             |
| Caesalpinia crista Linn.                   | Caesalpinaceae       |
| Carica papaya Linn                         | Caricaceae           |
| Cassica auriculata Linn                    | Caesalpinaceae       |
| C. occidentalis Linn                       | Caesalpinaceae       |
| Catharanthus roseum (Linn.) G. Don         | Apocynaceae          |
| Centratherum anthelminticum (L.) Kuntze    | Asteraceae           |
| Cinnamomum tamla Nees.                    | Lauraceae            |
| Citrullus colocynthis Schrad              | Cucurbitaceae        |
| Coccinia grandis (L.). Voigt.              | Cucurbitaceae        |
| Costus speciosus (Koen). Sm.               | Zingiberaceae        |
| Species                          | Family                  |
|---------------------------------|-------------------------|
| Curcuma longa Linn.             | Zingiberaceae           |
| Cyamposis tetragonoloba L. (Traub). | Fabaceae              |
| Decalepia hamiltonii Wight & Arn. | Asclepiadaceae         |
| Dioscorea bulbifera Linn.       | Dioscoreaceae           |
| Emblica officinalis (Gaertn.)    | Euphorbiaceae           |
| Gymnema sylvestre (Retz.) R. Br. Ex. Roemer & Schultz | Asclepiadaceae |
| Hordeum vulgare Linn.           | Poaceae                 |
| Ichnocarpus racemosa Hk. f.     | Asteraceae              |
| Kickzia ramosissima (Wall.) Jain | Apocynaceae             |
| Melia azadirachta Linn.         | Meliaceae               |
| Mangifera indica Linn.          | Anacardiaceae           |
| Momordica charantia Linn        | Cucurbitaceae           |
| Moringa oleifera Lamk.          | Moringaceae             |
| Murraya koenigii (Linn.) Spreng. | Rutaceae               |
| Ougenia dalbergioides Benth.    | Fabaceae                |
| Ocium sanctum Linn.             | Lamiaceae               |
| Paspalum scrobiculatum Linn.    | Poaceae                 |
| Phyllanthus amarus Schun & Thann| Euphorbiaceae           |
| Psidium guajave Linn            | Myrtaceae               |
| Pterocarpus marsupium Roxb.     | Fabaceae                |
| P. santalinus Linn.             | Fabaceae                |
| Rauwolfia serpentine Linn.      | Apocynaceae             |
| Rheum emodi Wall.               | Polygonaceae            |
| Solanum nigrum Linn.            | Solanaceae              |
| Strychnos potatorum Linn. F.    | Loganiaceae             |
| Swertia chirata Buch-Hamm       | Gentianaceae            |
| Syzygium alternifolium Walp.    | Myrtaceae               |
| S. cumini Linn.                 | Myrtraceae              |
| Talinum portulacifolium Wild.   | Portulacaceae           |
| Tecoma stansi (Linn.) Kunth     | Bignoniaceae            |
| Terminalia arjuna (Roxb.) ex DO. Datz et. Gibbs. | Combretaceae |
Some common antidiabetic plants

Apete et al\textsuperscript{8} studied antidiabetic activity of some indigenous plants. Others who studied hypoglycaemic plants were Nagarajan et al\textsuperscript{76} and Handa et al\textsuperscript{45}.

Some common plants used in hyperglycemia are as below:

1. *Syzygium cumini* Linn.

*S. cumini* belongs to family myrtaceae. It occurs from Himalaya to South India\textsuperscript{75}. The seed powder have been used in diabetes as it reduces the sugar in urine and ameliorates the unquenchable thirst. A glucoside jamboline, ellagic acid, tannin, gallic acid, chlorophyll, fatty oil, resin, sugar and traces of essential oil are also present\textsuperscript{106}. *S. cumini* was studied in detail by several workers\textsuperscript{1,19,90,102,115}. Suspensions of seed kernel of *S. cumin* 4g / dose level was found to show maximum antidiabetic effect (42.64\%) in rabbits 3h after medication\textsuperscript{75}. Nair and Santhakumar\textsuperscript{73} stated that like tolbutamide, drug of *S.cumini* may also be promoting endogenous release of insulin. It produced a significant decrease in the blood sugar level (17.04\%) in alloxan diabetic rats.

Further details can be obtained from Nagarajan et al\textsuperscript{76} and Handa et al\textsuperscript{45}.

2. *Pterocarpus marsupium* Roxb.

*P. marsupium* is known as Indian Kino tree, and belongs to family Fabaceae. The reports on hypoglycemic activity of *P. marsupium* is related to Pterostilbens, 3 – 4 dimethxystilbene\textsuperscript{9}. The activity pertaining to diabetes is matter of controversies\textsuperscript{43,63,95,97}. Mukherjee\textsuperscript{66} and Ray\textsuperscript{67} reported that *P. marsupium* had hardly any hypoglycemic activity. Apte et al\textsuperscript{8} confirmed the antihyperglycemic property with the extract of *P. marsupium*.

Antidiabetic activity has been discussed in detail by Handa et al\textsuperscript{45}.

3. *Melia azadirachta* Linn.

It is a member of family meliaceae. A perusal of literature vindicates that a few reports have been made pertaining to antidiabetic effect of *M. azadirachta*\textsuperscript{68,75,80}. *M.azadirachta* was found to be beneficial in lowering blood sugar level in dogs. Siddiqui\textsuperscript{103} reported that an active agent nimbidin is present in neem oil which is a potent antidiabetic agent in fasting and glucose fed rabbits. Apte et al\textsuperscript{8} supported that the diluted concentrate from the fresh leaves of neem reduces blood sugar significantly. The later persists for 12 days in blood sugar, if the treatment is continued.

4. *Momordica charantia* Linn.

It is a member of family cucurbitaceae. The fruits and leaves of *M. charantia* are very useful in diabetes\textsuperscript{27,101,114}. Chatterjee\textsuperscript{27} reported that fruit pulp is more effective in diabetes that the entire fruit. He found that extract of *M.charantia* can exert its
antidiabetic action in cases where the insulin secretion from pancreas has almost stopped. However, toxic effects have been experienced in large doses. Apte et al. reported that blood sugar level returned to the normal level with in 24 hours when extract of fruits of *M. charantia* was administered.

5. **Gymnema sylvestre (Retz.) Roemer & Schultz.**

*G. sylvestre*, commonly known as *Gurmar* is a member of family Asclepiadaceae. There is no taste of sugar after chewing the leaves of this antidiabetic herb. The leaves are used in diabetes. The effect remains up to half an hour. During the treatment of diabetes with this herb, one can eat sugar and starchy food. In Ayurveda, leaves of *Sala Saradhi* has been recommended for the control of maturity onset diabetes in addition to diet restriction\(^\text{[107]}\). *G. sylvestre* is a plant belonging to the group and has been described in Indian material medica\(^\text{[75]}\). Sushruta\(^\text{[107]}\) described this destroyer of Madhumeha (glycosuria) and other urinary disorders. Mhaskar and Caius\(^\text{[64]}\) studied the effect of leaves of *G. sylvestre*, Phytol, myoinositol and Scyllitol are present in leaves. Pannerselvam and Shanmughasundaram\(^\text{[70]}\) reported the hypoglycaemic activity of leaf powder in normal and diabetic men and rabbits.

They reported 15 or 30 percent reduction in the blood sugar level. Rajendra and Shanmugasundaram\(^\text{[86]}\) have shown that *G. sylvestre* is much effective in diabetes.

*G. sylvestre* has been discussed in detail by Nagarajan et al.\(^\text{[76]}\) and Handa et al.\(^\text{[45]}\).

Recently, researchers of Central Drug Research Institute, Lucknow while working with diabetes found that *Swertia chirata* induced significant fall in blood sugar and simulataneous increase in plasma immunoreactive insulin. It can also prove to be promising drug, if more investigation would be carried out.

**THE FUTURE**

Diabetes is increasing day – by – day, presently, insulin is the only drug before ailing patients. However, some crude drug of herbal origin are in use the market. Pills of *Momordica charantia* have already been prepared by the scientists. The investigators of CDRI Lucknow have worked out that *Swertia chirata* may be used in diabetes. The future of antidiabetic herbal drugs depend upon the extensive exploration of tribal pockets of India. The promising crude drug must be analysed in clinically manifested hyperglycaemia in the wake of thorough investigation of ethnomedicinal antidiabetic herbs.

**ACKNOWLEDGEMENTS**

The author is thankful to Professor R.C.Rajak for encouragement, and to Dr. K.K. Shrivastava for helpful suggestions. Thanks are also due to Dr. A.K. Agarwal, Assistant Director, Microbiology, CDRI, Lucknow for supplying literature on hyperglycaemia, and to Dr. D. Suresh Kumar, for critically going through the manuscript.
REFERENCES

1. Aiman, R., In symp, “Ind. Drugs”, Bombay, 1961, 9:3.

2. Aiman, R., Indian J. Physiol. Pharmacol., 1970, 14 : 65-70.

3. Ajgaonkar, S.S., Nagarjun, 1960 – 61, 4(3) : 275 – 86.

4. Anjaneyalu, B., Babu, B., Rao, V., Ganguly, A.K., Mannade, A.H., Mohamed, P.A., Rahimtula, A.D., Saksena, A.K., Varde, D.S. and Vishwanathan, N., Ind. J. Chem., 1965, 3:257.

5. Anjaneyalu, A.S.R., and Rama Prasad, A.V., Phytochemistry, 1982a, 21(8) : 2057.

6. Anjaneyalu, A.S.R., and Rama Prasad, A.V., Ind. J. Chem., 1982b, 21B(b),530.

7. Anjaneyalu, A.S.R., and Rama Prasad, A.V., Phytochemistry, 1983, 22(4) : 993.

8. Apte, I.C., Vaishwanar, I.P., Khannade, S.S., and Jadhav, S.N., Indian Drugs, 1988, 25(11) : 461 – 463.

9. Arora, R.B., and Stephen, P.M., Sec. Biol. Chem. Ind. 1959, 30:76.

10. Asatoor, A.M., and King, E. J., Biochem. J., 1954, 56: (IV- X).

11. Atal, C.K., Srivastava, J.B., Wali, B.K., Chakravraty, R.S., Dhawan, B.N., and Rastogi, R.P., Ind. J. Exp. Biol., 1978, 16 : 330.

12. Bansal, R., Ahmad, N., Kidwai, J.R., J. Biochem. Biophys., 1981, 18:377.

13. Basu, N.K., and chawdhary, K.D., Curr. Sci., 1960, 29:36.

14. Blatter, E., Caius, J.F., and Mhaskar, K.S., In: Indian Medicinal Plants, Vol. III, II, Edition, 1930, 1625 – 1627, Lalit Mohan Basu, Allahabad, India.

15. Bhargava, K.K., Dayal, R. and Seshadri, T.R., Curr. Sci., 1974, 43(20 : 645.

16. Bhattacharjee, A.K. and Das, A.K., Quarter. Jour. Crude Res., 1969, 9:408.

17. Bose, B.C., Vijayvargi, R., and Bose, S.N., Ind. J. Med. Sci., 1956, 9(10): 642.

18. Bose, S.C., Gupta, S.S. and Trivedi, C.P., Ind. J. Med. Sci., 1956, 10(9) : 700.

19. Bramchari, H.D., and Augusti, K.J., J. Pharm & Pharmac., 1961, 13, 38.

20. Bramchari, H.D., and Augusti K.J., J. Pharm & Pharmac., 1962, 14,254.
21. Bramchari, H.D., and Augusti K.J., *J. Pharm & Pharmac.*, 1962, 14, 617.

22. Casparie, A.F., and Miedema, R., *Lancet*, 1977, 11, 758 – 759.

23. Chakraborty, Ratna; Prasad, H.O., Studies on hypoglycaemic effect of Indigenous plant *Azadirachta India* A. Juss. in relation to other hypoglycaemic agent, paper presented in 79 Sci. Congress held at Aurangabad, 1992.

24. Chandola, H.M., Correlation of Prameha with diabetes mellitus and evaluation of the response of *C.tamala* on glucose and Insulin metabolism, Ph.D., Thesis, M.D., (ayu), I.M.K., B.H.U., 1979.

25. Chandola, H.R., Tripathi, S.N., and Udupa, K.N., *Ancient Sci. of Life*, 1988 7(3&4) : 219 – 226.

26. Charaka, Samhita, Commentary by Chaturvedy, G.N. and Shastri, K.N., IX. Edition, Chowkhamba Vidhyabhawan, Varanasi, 1980.

27. Chatterjee, K.P., *Ind. J. Physiol. Pharmacol.*, 1963, 7:240.

28. Chaudhary, R.R., and Vohara, S.B., Plants with possible hypoglycaemic activity in : *Advances in Research in Indian Medicine*, edited by K.N. Udupa, G. N. Chaturvedi and S. N. Tripathi, Banaras Hindu University, Varansi, 1970, 57 – 75.

29. Chopra, R. N., Nayyar, S.L., and Chopra, I.C., *Glossary of Indian Medicinal Plants*, CSIR, New Delhi, India, 1956, pp 53.

30. Davis, R.E., and Nicol., D.J., *Cong. Clin. Biochem*, 1980, 80 – 85.

31. Day, J.F., Ingebretsen, C.G., Ingebretsen, W.R., Jr., Baynes, J.W. and Thopre, S.R., *Diabetes*, 1980, 27: 524 – 527.

32. Dhar, M.L., Dhawan, B.N., Prasad, C.R., Rastogi, R.P. Singh, K.K. and Tandon, J.S., *Indian J. Exp. Biol.*, 1974, 12 : 512.

33. Das, P.K., and Mishra, M.K., *Ancient Sci. of Life*, 1988, 8(1) : 60 – 67.

34. Dhawan, B.N., Patnaik, G.K., Rastogi, R.P., Singh, K.K., and Tandon, J.S., *Ind. J. Exp. Biol.*, 1977, 15 : 208.

35. Dwivedi, S., Chawaouria, J.P., Somani, P.N., and Udupa, K.N., *Indian Drugs*, 1987 24 (8) : 378.

36. Dwivedi, S. and Udupan N., *Fitoterapia*, 1989, 60 (5) : 413.

37. Folin, O, and Wu, H., *J. Biol. Chem.* 1920, 41, 367.
38. Gharpurey, K.G., *Ind. Med. Gaz.*, 1926, 61, 155 (abstract).

39. Gracia, F., *J. Philippines Med. Assoc.*, 1955, 31, 216.

40. Gracia, F., *J. Philippines Med. Assoc.*, 1960, 36, 836.

41. Gupta, D.R., and Agarwal, S.K., *Sci. and Cult.*, 1970, 36 (5), 298.

42. Gupta, S.S., *I.J. Physiol. Pharmacol.*, 1962, 6, 23.

43. Gupta, S.S., Verma, C.L., Garg, V.P. and Khandelwal, P., *Ind. J. Med. Res.*, 1967, 55, 754.

44. Handa, S.S., Chawla, A.S., Maninder, *Fitoterapia*, LX(3); 195 - 224.

45. Hemadri, K., and S.S., Bhusan Rao., *Indian Medicine*, 1990, 2(1).

46. Hemadri, K., Sarma, C.R.P., and Rao, S.S., *Ancient Sci. of Life*, 1987, 6(3) : 167 – 186.

47. Hemadri, K., Sarma, C.R.P., and Rao, S.S., *Ancient Sci. of Life*, 1987, 7(1) : 55 – 60.

48. Henry, A.N., Kumari, G.R., and Chitra, V., *Flora of Tamilnadu*, India, Series 1, Analysis, Vol.2, B.S.I., Coimbatore, India, 1987.

49. Herbert, V., Lau, K.S., Gottlieb, C.W., and Bleicher, S.J., *J. Clin. Endocrinol.*, 1965, 25 : 1375 – 1384.

50. Hooper, D., *J. Sec. Chem. Ind.*, 1887, 6, 380.

51. Hooper, D., *Chem. News*, 59, 159.

52. Israili, A.H., *Nagarajun*, 1977, 20(12), 1 – 10.

53. Jain, M.C, and Seshadri, T.R., *Ind. J. Chem.*, 1975, 13 (1), 20.

54. Jain, S.K., Banerjee, D.K., and Pal, D.C., *Bull. Bot. Surv.*, India, 1973, 15 : 85 – 91

55. Jenkins, D.J.A., *Br. Med. J.*, 1978, 2 : 1744.

56. Joslin, E.P., Root, H.F., White, P., and Marble, A., *Treatment of Diabetes Mellitus*, 10th ed., Leaflbiger, 1959.

57. Kamboj, V.P., *Ind. J. Med. Res.*, 1988, 87, 336.

58. Karnick, C.R., *Acta Phytother. Amst*, 1972, 19(8) : 141 – 149.
59. Kirtikar, K.R., and Basu, B.D., *Indian Medicinal Plants*, Vol I & II, Bishen Singh, Mahendra Pal Singh, Dehradun, 1975.

60. Mathew, K.M., *The flora of Tamilnadu, Carnatie*, 3 parts. The Rapinet Herbarium, Trichirapalli, India, 1983.

61. Maya, S.J., Bibal, P.P., Mare, C., Pierre, B., *C.R. Acad, Sci, Ser.* (Fr.) 1967, 264, 1223.

62. Merelyn, A. Ma., Naughtn, A. and Cameron, D.P., *Clin, Chim.,* Acta, 1981, 115 :111 – 117.

63. Mhaskar, K.S., and Caius, J.F., *Indian Medical Research Memories*, 1930.

64. Mukerji, B., *J. Sci, Industr, Res.*, 1957, 16A (Suppl), 1 – 18.

65. Mukherjee,S.K.,De, U.N. and Mukherjee, B., *Indian Med.Res. Gaz.*, 3(1),(1963–64),97– 104.

66. Mukherjee, K., and Ray, L.M., *Ind. J. Crude Drug Res.*, 1986, 24 (4), 187.

67. Murty, K.S., Rao, D.N., Rao, D.K., and Murty, L.B.C., *Ind. J. Pharmac.*, 1978, 10 : 247.

68. Nagar, A., Gujral, V.K. and Gupta, S.R., *Planta Med.*, 1979, 37(2), 183.

69. Nagar, A., Gujral, V.K. and Gupta, S.R., *Phytochemistry*, 1979, 18(7), 1245.

70. Nagaraju, N., and Rao., K.N., *Ancient Sci, of Life*, 1989, 9(1), 31- 35.

71. Nair, A.G.R., and Sankara, Subramaniyam, S.J., *J. Sci. Indus. Res.*, 1962, 21 (b), 457.

72. Nair, B.R., and Santhakumari, G., *Ancient Sci. of Life*, 1986, 6(2), 80 – 84.

73. Nair, N.C., and Henry, A.N., *Flora of Tamilnadu, India*, Series 1, Analysis, Vol. I, B.S.I., Coimbatore, India, 1983.

74. Nadkarni, A.K., *India Materia Medica*, 1954, 281.

75. Nagarajan, S., Jain, H.C., and G.S. Aulakh. *In Cultivation and utilization of medicinal plants*, Regional Research Lab., CSIR, Jammu-Tawi, pp 877.

76. Nadkarni, K.M., *Indian Materia Medica*, (revised and enlarged edition by A.K. Nadkarni) Vol. L, Popular Prakashna, Bombay, 1976.

77. Niebee, P., *Clin. Chem. Acta*, 1972, 42 : 399 – 403.

78. Pannerselvam, C., and Shanmugasundaram, K.R., *J. Madras Univ.*, 1978, (Section B), 41: 171- 183.
79. Pillai, N.R., and Shanta Kumari, G., *Ind. J. Med. Res.*, 1981, 74, 931.

80. Prabhakar, Y.S., and S. Kumar, *Plant Med. Phytother*, 1988, 22(1), 30.

81. Pathak, S.R., Upadhyaya, L. Singh, R.V., Dubey, G.P., and Udupa, K.N., *Indian Drugs*, 1990, 27(4), 221.

82. Power, F.B., and Tutin, F., In: *Indian Materia Medica* – revised and enlarged by Dr. A. K. Nadkarni, III. Edn. Vol.I, 596 – 599, Popular book Depot, Bombay, 1904.

83. Rajaram Rao, M.R., Ambika, S.H., Gandhi, V.M., and Murthy, R.V., *Ind. J. Pharm.*, 1966, 28(912), 345.

84. Rajendran, V.M., Metabolite and functional studies on the intestine in streptozotocin induced diabetes controlled by *Gymnema sylvestre* R. Br. Doctoral Thesis, University of Madras.

85. Rajendran, V.M., and Shanmugasundaram, K.R., *J. Madras Univ.*, 1980, Section B, 43 : 62-69.

86. Ramachandran, R.L., Suryanarayanan, Murthy, P., Subba Rao, G.S.R., Sastry, C.S.P., and Rao, K.V.J., *Ind. J. Chem.*, 1970, 8(8) : 716.

87. Ramachandran, R.L., Suryanarayana, Murthy, P. Subba Rao, G.S.R., Sastry, C.S.P., and Rao, K.V.J., *Ind. J. Chem.*, 1970, 8(9) : 772.

88. Rao, Sahab, Rama Rao, M., *Flowering Plants of Travancore*, Govt. Press, Trivandrum, 1988.

89. Renu, Bansal, Nafesahmed, and Jalil, R., Kidwai, *Ind. J. Biochem, Biophys*. 1981, 18, 377.

90. Sankarasubramaniyam, S., and Nair, A.G.R., *Curr. Sci.*, 1972, 42 (19) : 703.

91. Santhoshkumari, K.S. and Devi, K.S., *Ancient Sci. of Life*, 1990, 9(4) : 22 – 223.

92. Sastri, N.N., *A dictionary of Indian raw materials and Industrial products*, Vol. IV., CSIR, Delhi, 1956.

93. Sengupta, P., and Dass, S.P., *J. Ind. Chem. Soc.*, 1965, 42, 539.

94. Sepa, A.C., and Bose, S.N., *J. Ind. Med. Assoc.*, 1956, 27, 388.

95. Seth, S.D.S., Arora, R.B. and Maurya, D.P.S., *Ind. J. Pharm.*, 1972, 4(2), 130.

96. Shah, D.S., *Ind. J. Med. Res.*, 1967, 55, 166.

97. Shanmugasundaram, K.R., Pannerselvam, C. Lalitha, T., and Ranibai, A.J., *Arogya J. Health*, 1981, 7, 38-60.
98. Sharaf, A.A., Hussein, A.M. Mansour, M.Y., *Plants Medica*, 1963, 11, 159.

99. Sharma, P.N., Shoeb, A., Kapil, R.S. and Popli, S.P., *Ind. J. Chem.*, 1982, 21 B(3), 263.

100. Sharma, V.N., Sogani, R.K., and Arora R.B., *Ind. J. Med. Res.*, 1960, 48, 471.

101. Shorti, D.S., Kelker, M., Desmukh, K., and Alman, R., *Ind. J. Med. Res.*, 1963, 51, 464.

102. Siddiqui, S.A., *Curr. Sci.*, 1942, 11, 278.

103. Singh, T.N., Upadhyay, B.N., Tewari, C.M., Tripathi, S.N., *Ancient Sci. of Life*, 1985,5(1),9-16.

104. Standl, E., and Kolb, H.J., *Diabetologia*, 1973, 9 : 461 – 466.

105. Steinmetz, E.F., *Acta Phytotherapeut.*, 1960, 7, 23.

106. *Sushruta Samhita*, Hindi commentary by Shastri, K.A., Chaukhambha Sanskrit Series, III, edition, Varanasi, 1973.

107. Svobada, G.H., Gorman, M., Root, M., *Lloydia*, 1964, 27, 361.

108. Tettamanti, G., Bonali, F., Marchesini, S., and Zambothi, V., Biochem. *Biophyse Acta*, 1973, 296, 160 – 170.

109. Tiwari, A.K., Gode, J.D. and Dubey, G.P., *Ind. Drugs*, 1989, 26 (12), 664.

110. Tomoda, M., Shimizu, N., Oshima, Y., Takahashi, M., Murakami, M., Hikino, H., *Planta Medica*, 1987, 8.

111. Tripati, C.P., Tewari, C.M., Upadhyay, B.N., Singh, R. J., J. Res. *Ind. Med.*, 1979, *Homeo & Yoga*, 14 : 3

112. Trivedi, C.P., *Ind. J. Physiol. Pharmacol.*, 1963, 7, 11.

113. Vad, B.G., *Ind. J. Pharmac.*, 1961, 23, 115.

114. Vaish, S.K., *Ind. Sci., Congress Assoc.*, 1954, 230.

115. Wagner, W.D., *Annal. Biochem.*, 1979, 94, 394 – 397.

116. Yadav, B.L., Mathur, R., and Gupta, R.B., *Probe*, 1980, 19(3), 196.

117. Yus, D.K., Morris, K., Mo Lennon, S., and Turtle, J.R., *Diabetes*, 1980, 29 : 296 – 300.