IN VITRO ALPHA-GLUCOSIDASE INHIBITORY ACTIVITY OF EGYPTIAN PLANT EXTRACTS AS AN INDICATION FOR THEIR ANTIDIABETIC ACTIVITY

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ABSTRACT

Objective: Diabetes mellitus is a highly prevalent chronic disease in Egypt leading to high socioeconomic problems, especially in the cities due to the unhealthy life style. Although many drugs are available, they have many side effects. Furthermore, the body arouses resistance after a while for the drugs so it should be changed every once in a while. Plants could be a good source for drugs. In Egypt, we have a rich flora which has not been subjected to systematic screening for antidiabetic activity.

Methods: The aim of this work was to screen 264 plant extracts for their in vitro α-glucosidase inhibitory activity. Those extracts which gave more than 70% inhibition were screened on different concentrations and their inhibitory concentrations giving 50% activity (IC_{50}) were calculated.

Results: Out of all the tested extracts, 63 gave more than or equal 70% inhibition on α-glucosidase at the tested concentration (25 ppm). After the calculation of the IC_{50} values, 10 extracts were chosen for further study having 5 ppm and less IC_{50}.

Conclusion: The most active plant extract is Pinus roxburghii Sarg. branches (IC_{50} is 2.47 ppm).

Keywords: Antidiabetic, Alpha-glucosidase, In vitro, Plant extracts, Bioassay, Egyptian.

INTRODUCTION

Diabetes is a complex metabolic condition where the patient suffers a chronic increase in blood glucose concentration (hyperglycemia) since the body cannot properly utilize it [1-4].

Diabetes mellitus is a highly prevalent chronic disease in Egypt leading to high socioeconomic problems, especially in the cities due to the unhealthy life style. Although many drugs are available, they have many side effects. Furthermore, the body arouses resistance after a while for the drug so it should be changed every once in a while.

It is noteworthy that therapeutic pathways for type 2 diabetes mellitus are based on the following: Stimulation of insulin secretion, reducing the production of glucose from the liver, interfering with the metabolism and digestion of carbohydrates (our target), and optimizing insulin action [5].

Plants and natural products could represent an excellent source for drugs since they can provide new compounds which cannot be predicted by computational chemistry [6].

The α-glucosidase enzyme is responsible for changing oligo and disaccharides into monosaccharides. In case it is inhibited, the blood concentration of glucose decreases since only monosaccharides can be absorbed through intestinal mucosa [7] thus reducing the demand for insulin.

The aim of this work was to begin a series of diabetes-related in vitro screening program, studying the Egyptian flora. Since no systematic Egyptian large scale bio-study was done in that area before, we find it of great interest to undergo such a study.

The paper at hand, aimed to screen 264 plant extracts for their in vitro α-glucosidase inhibitory activity.

METHODS

Preparation of the plant extracts
Seventy five grams of dried plant powder were percolated in 450 ml 95% analytical grade methanol (ADWIC-Egypt) for 24 h in a stainless steel percolator. The percolate was vacuum dried using Büchi R-114 rotatory evaporator at 45°C. The distillate was used for re-percolation of the marc and the same procedure was adopted. The dried extract was kept in the dark at −20°C till its use [8].

Preparation of the stock solutions of plant extracts for bioassays
Ten mg of the dried methanol plant extract are dissolved in 500 µl dimethyl sulfoxide (stock solution A). Master plates for the extracts to achieve different concentrations are prepared as follows: 5 µl from the stock solution A + 195 µl buffer (stock B); 100 µl from the stock solution B + 100 µl buffer (stock C); 100 µl from the stock solution C + 100 µl buffer (stock D); and 100 µl from the stock solution C + 100 µl buffer (stock D).

α-glucosidase inhibitory activity
Briefly α-glucosidase (Sigma G5003-100UN-USA) of concentration 0.2 U/ml is prepared in phosphate buffer saline (0.2 M) (pH 6.8) (35.084 g Na₂HPO₄ [Loba Chemie-05971 00500] + 13.872 g KH₂PO₄ [x.d.fine-Chem ltd. BOISAR 39608]). 10 µl of sample at varying concentrations are mixed with 60 µl of 0.2 U/ml α-glucosidase and incubated for 20 min at 37°C in a 96 well plate. The 150 µl of 1.25 mM p-nitrophenyl α-D-glucopyranoside (p-NPG) (Sigma N1377-5g-USA) are added and incubated at 37°C for 20 min giving final concentrations of 0.2 to 25 ppm in the final volume. The reaction is terminated by the addition of 50 µl of 2 g/L sodium hydroxide (NaOH). α-glucosidase activity is determined spectrophotometrically at 405 nm by measuring the quantity of bright yellow p-nitrophenol released from the colorless p-NPG. The negative control has 10 µl of buffer solution in place of the test entity while acarbose is used as a positive control. For blank p-NPG with buffer solution is added instead of the enzyme [9,10].
Calculation of the result:

The percentage inhibition = \( \frac{1 - \text{average of sample absorbance/average of negative control absorbance}}{1} \times 100 \)

RESULTS

Two hundred and sixty four plant extracts (25 ppm) were screened for their α-glucosidase inhibitory activity (Table 1).

Out of all the tested extracts, 63 gave more than or equal 70% inhibition on glucosidase at the tested concentration, where their IC\(_{50}\) values were calculated (Tables 2 and 3). IC\(_{50}\) of acarbose as a positive control is 45±2.7 ppm. By reviewing the results, the most active plant extract proved to be *Pinus roxburghii* Sarg. branches methanol extract (IC\(_{50}\) is 2.47 ppm).

DISCUSSION

The present study was designed for the purpose of screening a part of the Egyptian flora for their antidiabetic properties. Where a huge number of animals would be needed for the purpose, the resort to a simple *in vitro* method pointing out the plants which can be chosen as candidates for deeper *in vivo* studies is adopted. This paper is the beginning step in a much longer path so as to reach an effective antidiabetic drug from natural origin.

By reviewing our findings, several plant extracts showed significant results in blocking the α-glucosidase enzyme ability to break down starch, which, in turn, would decrease the blood glucose level. *Pinus roxburghii* Sarg. being the most active plant was subjected to a literature survey. The survey showed that the bark alcohol extract has

| Genus species                        | Part                   | Activity on α-glucosidase (%) |
|--------------------------------------|------------------------|-------------------------------|
| Acacia ehrenbergiana Hayne           | Fr                     | 13                            |
| Acacia saligna (Labill.) H.L.Wendl.  | L, Fl and Fr           | 1                             |
| Acalypha wilkesiana Mull. Arg. Cv. Hoffmanianum | L               | 100                           |
| Acer negundo L.                      | Bark                   | -24                           |
| Acer oblongum Wall. ex DC.           | H                      | 12                            |
| Achillea fragrantissima (Forssk)Sch  | H                      | 15                            |
| Achras sapota L.                     | L                      | 100                           |
| Adenanthera pavonina L.              | Bark                   | 10                            |
| Aegilops ventricosa (Zhuik.) Chennav.| H                      | 15                            |
| Aegle marmelos (L) Corrêa            | Inflorescence          | 16                            |
| Aggeratum houstonianum Mill          | Br                     | 21                            |
| Albizia stipulata Bov.              | L, Br and Fl           | 16                            |
| Albizia lebbec (L) Benth.            | L                      | 12                            |
| Alhagi graecorum Boiss.              | H                      | 3                             |
| Allkanna orientalis (L) Boiss.       | Br                     | 43                            |
| Aloe arborescens Mill               | Shoot system           | 16                            |
| Amaranthus graecians L.              | H                      | 0                             |
| Anagallis arvensis L.                | H                      | 0                             |
| Anredera baselloides (HBK) Bail      | L and Br               | 26                            |
| Aptenia cordifolia (LJ.) Schwant.    | L                      | 27                            |
| Arisarum vulgare vvesligii            | H                      | 0                             |
| Artemisia judaica L.                 | H                      | 0                             |
| Astragalus fruticosus Forssk.        | H                      | 0                             |
| Atriplex halimus L.                  | H                      | 9                             |
| Atriplex portulacoides L.            | H                      | 11                            |
| Atriplex semibaccata R.Br.           | H                      | 21                            |
| Avena sterilis L.                    | H                      | 0                             |
| Ballota kaiseri Tackh.               | Br                     | 0                             |
| Baugainvillea galbra Choisy          | Bark                   | 0                             |
| Bauhinia hookeri FJ.Muell.           | L and Br               | 100                           |
| Bauhinia variegata (L) Benth.         | Fr with seeds          | -15                           |
| Beta vulgaris L.                     | Weed                   | 30                            |
| Bombax malabaricum DC.               | L                      | 100                           |
| Bougainvillea spectabilis Wild.      | L and Br               | 17                            |
| Brassaia actinophylla Endl.          | L and Br               | 78                            |
| Brassica nigra L.                    | Weed                   | 19                            |
| Brassica oleracea L.                 | Weed                   | 23                            |
| Caesalpinia ferrae C.Mart.           | L and Fl               | 3                             |
| Calligonum comosum L.Heer.           | Br                     | 32                            |
| Calligonum polygonoides L.           | H                      | 99                            |
| Campsis radicans (L) seem.ex Bur.    | Br                     | 33                            |
| Capsella bursa-pastoris (L) Medik.    | Weed                   | 20                            |
| Caryota urens L.                     | Fr                     | 100                           |
| Cassia Fistula L.                    | Br                     | 100                           |
| Cassia renegra Wallich ex Benth.     | L                      | 26                            |
| Celosia argentea L.                  | Br, Fr and Bark        | 19                            |
| Chenopodium ficifolium Sm.           | Weed                   | 15                            |
| Chortisa insignis (A.St-Hil.) Ravenna | Bark                   | 99                            |
| Genus species                      | Part                  | Activity on α-glucosidase (%) |
|-----------------------------------|-----------------------|-------------------------------|
| Chrysophyllum oliviforme L.       | Br                    | 100                           |
| Cichorium endivia L.              | Weed                  | 16                            |
| Cissus rotundifolia (Forssk.) Vahl| L and Br              | 0                             |
| Citharexylon quadrangularis Jacq. | Br                    | 0                             |
|                                  | Bark and Wood         | 14                            |
| Citrullus colocynthis (L.) Schrad.| Fr                    | 0                             |
| Citrus aurantiifolia (Christm.) Swingle | Shoot system    | 24                            |
| Cleome amblyocarpa Bar. and Mur.  | L and Br              | 14                            |
| Cleome chrysanthra Decne.         | H                     | −30                           |
| Cleome drosifera (Forssk.) Del.   | Bark                  | −17                           |
|                                  | H                     | 10                            |
| Clerodendrum inermis L.           | H with Fl             | 0                             |
| Clerodendrum splendens G. Don.    | Br                    | 5                             |
| Clovia miniata Regri             | L                     | 27                            |
| Coccoloba peltata Schott         | L                     | 39                            |
| Convolvulus arvensis L.           | Weed                  | 15                            |
| Cordia gharaf (Forssk.) Ehrenb.ex Asch. | L and Br      | 2                             |
|                                  | Br                    | 2                             |
|                                  | Bark                  | 11                            |
| Cordia myxa L.                   | H                     | 7                             |
| Cornus nilotica (Dehile) Spreng.  | Wead                  | 15                            |
| Cornulaea moncanatha Deile       | Bark                  | 19                            |
| Cressa cretica L.                | H                     | 0                             |
| Cynanchum acutatum L.            | L and Fl              | 43                            |
| Dactyloctenium aegyptium (L.) Willd. | L                     | 0                             |
| Datura stramonium L.             | H with Fr             | 3                             |
| Delima indica L.                | Br                    | 13                            |
| Delonix regia (Boj. ex Hook.) Raf.| Fl                    | 74                            |
| Dendrocalamus strictus (Roxb. Nees) | L and Fl          | 14                            |
| Derris robusta (Roxb. ex DC.) Benth. | L and Fl          | 89                            |
| Dipotaxis harra (Forssk.) Boiss.  | Br                    | 87                            |
| Dombea tiliaeæ (Endl.) planch    | Br                    | 50                            |
| Encephalartos villosus Lem.      | Male Cone             | 100                           |
| Ephedra alata Decne.             | L                     | 5                             |
| Ephedra aphylla Forsskål         | H                     | 100                           |
| Erlobotrea japonica (Thumb.) Lindl. | Br                | 64                            |
| Erodium cicutarium (L.) L'Hér. ex Alton | L                    | 59                            |
| Eruca sativa Mill.               | H                     | 52                            |
| Erythrina indica Lam.            | Bark                  | 32                            |
| Eucalyptus citriodora (Hook.) K.D. Hill and L.A.S.Johnson | L and Br | 0                             |
| Eucalyptus rostrata Schidl.      | Bark                  | 95                            |
| Eugenia uniflora L.              | L                     | 97                            |
| Euphorbia cotinifolia L.         | H                     | 26                            |
| Euphorbia ingens E.Mey. ex Boiss. | Bark                  | 37                            |
| Euphorbia peplus L.              | Weed                  | 45                            |
| Euphorbia pulcherrima Wild. Ex. Kolotzch. | L                  | 23                            |
| Euphorbia retusa Forssk.         | H                     | 27                            |
| Feronia elephantum Corrêa        | Bark                  | −23                           |
| Ficus afzelii G.Don              | Bark                  | 100                           |
|                                  | L                     | 75                            |
|                                  | Br                    | 56                            |
| Ficus bengalensis L.             | Aerial Roots          | 67                            |
| Ficus cyathistipula Warb.        | L                     | 11                            |
| Ficus decora Hort. Cv. Variegata  | H                     | 28                            |
| Ficus elastica Roxb. ex Hornem.   | Bark                  | 100                           |
| Ficus erioskonydes (Ficus afzelii G. Don.) | Br       | 22                            |
| Ficus palmata Forssk. Sub. Sp. Virgata (Roxb.) | Br       | 24                            |
| Ficus platyphyllo Delile         | Br                    | 25                            |
| Ficus pyriformis L.              | Shoot system          | 21                            |
| Ficus sperguana L.               | Bark                  | 100                           |
|                                  | H                     | 96                            |
| Flacourtia cataphracta Roxb. ex Wild. | L                  | −11                           |
| Halocnemum strobilaceum (Pal.) Bieb. | H                   | 17                            |

(Contd..)
| Genus species                                                                 | Part       | Activity on α-glucosidase (%) |
|------------------------------------------------------------------------------|------------|------------------------------|
| Harpephyllum caffrum Bernh. ex C.Krauss                                      | Br         | 6                            |
| Harpullia cupanioides Roxb.                                                   | Bark       | 6                            |
| Br                                                                           | 83         |
| L                                                                           | 0          |
| H                                                                           | 15         |
| Heliotropium digynum (Forssk.) Aschers. ex C. Christ.                        | H          | –6                           |
| Hippeastrum vittatum (L.Her.)                                                 | Br         | 20                           |
| Hyphaene thebaica (L.) Mart.                                                  | Br         | 0                            |
| Iphiona scabra DC. ex Decne.                                                  | 0          |
| Jasminum primulinum Hemszl.                                                   | Br         | 18                           |
| L                                                                           | 33         |
| Juncus rigidus Desf.                                                         | H          | 0                            |
| Khaya dewi A.Juss.                                                           | L and Br   | 30                           |
| L                                                                           | 0          |
| Khaya senegalensis (Desr.) A.Juss.                                           | L          | 66                           |
| L                                                                           | Br         | 83                           |
| Bark                                                                        | 97         |
| Koelreuteria elegans (seem.) A.C, Sm.(Koelreuteria henryi) Dummer)           | L          | 96                           |
| Koelreuteria paniculata Laxm.                                                 | Br         | 100                          |
| Lagerstroemia indica (L.) Pers.                                               | Br         | 87                           |
| Lamium amplexicaule L.                                                        | Weed       | 23                           |
| Lantana camara L.                                                            | Br         | 0                            |
| Lasiurus hirsutus (Forsk.) Boiss.                                             | L          | 20                           |
| Launaea spinosa (Forsk.) Sch.Bip.                                             | H          | –5                           |
| Leucaena glauca L. Benth.                                                     | H with Fl and Fr | 27   |
| L                                                                           | 32         |
| Liomoniastrum monopetalum (L.) Boiss.                                         | L, Br and Fl | 8    |
| Lonicer japonica Thunb.                                                       | 100        |
| Lotus tenuis Waldst. and Kit. ex Wildl.                                        | L and Br   | 23                           |
| Weed                                                                        | 16         |
| Synonyms Lotus glaber Mill.                                                   |            |                              |
| L. corniculatus subsp. tenuifolius L.                                         | L and Br   | 31                           |
| Lycium europaeum L.                                                           |            |                              |
| Lycium shawii Roem and Schult.                                                | H          | 10                           |
| Macadamia integrifolia Maiden and Betch.                                      | Br and L   | 26                           |
| Maclura pomifera (Raf.) Schneid.                                              | Bark       | 0                            |
| Magnolia grandiflora L.                                                       | Bark       | –15                          |
| Melia azedarach L.                                                            |            |                               |
| Melilotus indicus (L.) All.                                                   | Weed       | 25                           |
| Mesembryanthemum nodiflorum L.                                                | Weed       | 19                           |
| Montanoa bipinnatifida (Kunth) K.Koch                                        | L          | –26                          |
| Morretta philoena (Del) DC                                                    | Br         | 2                            |
| Moretta alba L.                                                               | Br         | 2                            |
| Morus alba L.                                                                | L and Br   | 32                           |
| Morus nigra L.                                                                | Bark       | 99                           |
| Myoporum laetum G. Forst.                                                     | H          | 5                            |
| Nitaria retusa (Forssk.) Asch.                                                | H          | 0                            |
| Ononis vaginata Vahl                                                         | H          | 16                           |
| Oreopanax reticulatum Willd.                                                  | Fr         | 0                            |
| Panicum turgidum Forssk.                                                     | H          | 20                           |
| Parietaria judaica L.                                                         | L and Br   | 30                           |
| Parkinsonia aculeata L.                                                      | L          | 30                           |
| Paspalidium geminatum (Forsk.) Stapf.                                         | H          | 0                            |
| Phlomis aurea Decne.                                                         | Shoot system | 25  |
| Phoenix dactylifera L.                                                        | Pulp       | 0                            |
| Pinus canariensis C.Sm.                                                       | Fr         | 100                          |
| Pinus halapensis Mill                                                        | L          | 100                          |
| Pinus pinea L.                                                               | Br         | 100                          |

(Contd...)
| Genus species                                      | Part                  | Activity on $\alpha$-glucosidase (%) |
|---------------------------------------------------|-----------------------|--------------------------------------|
| Pinus roxburghii Sarg.                            | L                     | 99                                   |
|                                                    | Fr                    | 30                                   |
|                                                    | Br                    | 99.50                                |
| Pistacia chinensis Bunge                          | L and Fr              | 11                                   |
| Pithecellobium dulce (Roxb.) Benth.               | L and Unripe Fruit    | 0                                    |
| Pluotus rubra L.                                  | L, Br and Fr          | 15                                   |
| Polyscias paniculata (DC.) Baker                  | Br                    | 100                                  |
| Psidium guajava L.                                | Br                    | 99                                   |
|                                                    | L                     | 99                                   |
| Pterospermum acerifolium (L.) Wild.               | Br                    | 17                                   |
| Punicia incisa (Lam.) DC.                         | H with Fl             | 0                                    |
| Putranjiva roxburghii Wallich                     | Br                    | 47                                   |
|                                                    | L                     | 100                                  |
| Pyracantha fortuneana (Maxim.) H.Li (Pyracantha   | L                     | 88                                   |
| creneto-serrata Hance Rehd)                       |                       |                                       |
| Pyrethrum santoloinoides (Tanacetum santoloinoides)| H                   | 0                                    |
| Pyrus communis L.                                 | Shoot system          | 42                                   |
| Ranunculus seleratus L.                           | H                     | 0                                    |
| Reseda pruinosa Delile                           | H                     | 9                                    |
| Rumex dentatus L.                                 | Weed                  | 92                                   |
| Sabal peregrina L.H. Bailey                       | L                     | 9                                    |
| Salvia kali L.                                    | H                     | 10                                   |
| Sambucus nigra L.                                 | Bark                  | 0                                    |
| Saraca caulisfioro Bak.                           | L                     | 91                                   |
| Schefflera arboricola (Hayata) Kanehira           | Shoot system          | 30                                   |
| Senecio glaucus L. Synonyms Senecio coronopifoliusDesf| Weed                | 23                                   |
| Senna surattensis (Burm. f.) H. Irwin and Barneby | Br                   | 98                                   |
| Sesbania sesban (L.) Merr.                        | L and Br              | –17                                  |
| Shinopsis balansea Engl                           | Br                    | 98                                   |
| Silene rubella L.                                 | Weed                  | 19                                   |
| Silybnum marianum (L.) Gaertn.                    | Weed                  | 23                                   |
| Sonichus oleraceus L.                             | W                     | 20                                   |
| Spathodea nilotica Seem.                          | L and Br              | 19                                   |
|                                                    | Fl                    | 6                                    |
| Spondias lutea L.                                 | L                     | 89                                   |
|                                                    | Fr                    | 100                                  |
|                                                    | Br                    | 100                                  |
| Stachys aegyptica Pers.                           | H                     | 0                                    |
| Stellaria pallida (Dumort.) Piré                  | Weed                  | 34                                   |
| Sterculia foetida L.                              | L                     | 51                                   |
|                                                    | Br                    | 100                                  |
| Suarea aegyptica (Hasselq.) Zohary                | H                     | 17                                   |
| Suarea pruinosa Lange                             | H                     | 32                                   |
| Suarea vera Forsk. ex J.F.Gmel.                  | H                     | 0                                    |
| Swietenia macrophylla King                        | L                     | 62                                   |
| Swietenia mahagoni (L.) Jacq.                     | L                     | 100                                  |
|                                                    | Br                    | 100                                  |
|                                                    | Bark                  | 42                                   |
| Tecoma radicans (L.) Juss.                        | L and Br              | 14                                   |
| Tecoma stans (L.) Juss. ex Kunth                  | H                     | 21                                   |
|                                                    | L                     | 26                                   |
| Terminalia angustifolia Blanco                    | Br                    | 0                                    |
| Terminalia arjuna (Roxb.) Wight and Arn.         | Br                    | 100                                  |
| Terminalia bellirica (Gaertn.) Roxb.              | Br                    | 12                                   |
| Teusarium polium L.                               | H                     | 0                                    |
| Tipuana tipu (Benth.) Kunzte                      | Bark                  | 36                                   |
| Trifolium repentinum L.                           | L                     | 23                                   |
| Trigonella stellata Forsk.                        | H                     | 0                                    |
| Ulmus parvifolia Jacq.                            | L                     | 50                                   |
| Verbascum sinaiticum Benth.                       | Br                    | 4                                    |
| Verbena x hybrida Ross.                           | L                     | 15                                   |
| Vicia sativa L.                                   | Weed                  | 12                                   |
| Woodfordia fruticos (L.) Kurz                     | Bark                  | 4                                    |
| Xanthium spinosum L.                              | H                     | 0                                    |
| Zilla spinosa (L.) Subsp. Parmata                 | Br                    | 12                                   |
| Zygophyllum album L.                              | L                     | 20                                   |
| Zygophyllum decumbens Delile.                     | Aerial part            | 12                                   |

H: Herb, Fr: Fruits, Fl: Flowers, L: Leaves, Br: Branches
Table 2: The percentage inhibition of extracts which gave ≥70% at 25 ppm on α-glucosidase on different concentrations to be used in the calculation of the IC values

| Genus species                              | Part | Activity on α-glucosidase (%) |
|--------------------------------------------|------|-------------------------------|
| Acacia saligna (Labill.) H.L. Wendl.       | Br   | 37                            |
| Acalypha wilkesiana Mull. Arg. Cv. Hoffmannianum | L    | 30                            |
| Achras sapota L.                           | L    | 15                            |
| Bauhinia hookeri F.J. Muell.               | L    | 34                            |
| Bauhinia variegata (L.) Benth.             | Br   | 25                            |
| Bombax malabaricum DC.                     | Bark | 48                            |
| Brassia actinophylla Endl.                 | Bark | 24                            |
| Calligonum polygonoides L.                 | H    | 50                            |
| Caryota urens L.                           | L    | 27                            |
| Cassia Fistula L.                          | Bark | 40                            |
| Cassia renegr L.                           | L    | 40                            |
| Chorisia insignis (A.St.-Hil.) Ravenna      | Bark | 50                            |
| Chrysophyllum oliviforme L.                | Br   | 46                            |
| Derris robusta (Roxb. ex DC.) Benth.       | L    | 8                             |
| Encephalartos Male Cone                     | Bark | 32                            |
| Ephedra aphylla Forsskål                   | Herb | 17                            |
| Eucalyptus citriodora (Hook.) K.D. Hill    | Bark | 20                            |
| and L.A.S. Johnson                         |      |                               |
| Eucalyptus rostrata Schidtl.               | Bark | 73                            |
| Eugenia uniflora L.                        | L    | 43                            |
| Ficus afzelii G. Don                       | Bark | 16                            |
| Ficus elastica Roeb. ex Hornem.            | Bark | 40                            |
| Ficus eriobotryoides (Ficus afzelii G. Don.)| Bark | 20                            |
| Ficus sperruana L.                         | L    | 12                            |
| Harpullia cupanoides Roxb.                 | Bark | 10                            |
| Khaya senegalensis (Desr.) A.Jus.s.        | Br   | 13                            |
| Koelreuteria elegans (seem.) A.C, Sm. (Koelreuteria henryi Dummer) | L    | 60                            |
| Lagerstroemia indica (L.) Pers.            | Br   | 0                             |
| Liomoniastrum monopetalum (L.) Boiss.      | Herb | 11                            |
| Mangifera indica L.                        | L    | 35                            |
| Morus nigra L.                             | Bark | 55                            |
| Pinus canariensis C.Sm.                    | Fr   | 50                            |
| Pinus halepensis Mill.                     | L    | 12                            |
| Pinus pinea L.                             | L    | 60                            |
| Pinus roxburghii Sarg.                     | Br   | 67                            |
| Pithecellobium dulce (Roeb.) Benth.        | Br   | 38                            |
| polycics paniculata (DC) Baker             | Br   | 24                            |
| Podium guajava L.                          | Br   | 19                            |
| Putranjiva roxburghii Wallich              | L    | 30                            |
| Pyracantha fortuneana (Maxim) H.L.L.i (Pyracantha creneto-serrata (Hance Rehd)) | B    | 47                            |
| Rumex dentatus L.                          | Weed | 4                             |
| Senna surattensis (Burm. F.) H. Irwin and Barneby | Br | 32                            |
| Shinopsis balansea Engl                    | Bark | 41                            |
| Spondias lutea L.                          | L    | 51                            |
| Sterculia foetida L.                       | L    | 17                            |
| Swietenia mahagoni (L.) Jacq.              | Br   | 50                            |
| Terminalia arjuna (Roeb.) Wight and Arn.   | Br   | 60                            |

H: Herb, Fr: Fruits, Fl: Flowers, L: Leaves, Br: Branches
anti-inflammatory and analgesic effect [11], the wood oil of the plant possesses hepatoprotective activity, and the essential oil of the needles is antibacterial and antifungal [12]. The antidiabetic in vivo activity of the bark extract and its hypolipidemic property were studied, where it proved to have a hypoglycemic effect [13]. The fore-mentioned result conforms to our work on the branches of the same plant. It was also studied as a protective for gastric ulcers [14] and for its antibacterial activity [15].
CONCLUSION

After the calculation of the IC values, 10 extracts were chosen having 5 ppm and less IC \(_{50}\) which will be subjected to further extensive in vivo studies.

ACKNOWLEDGMENT

This work was financed by the National Research Centre, Egypt, under the project “Search of a novel anti-diabetic drug from natural origin,” contract agreement number 11010309 (2016-2019), Principal Investigator May A El-Manawaty.

AUTHORS CONTRIBUTIONS

Both authors contributed in the preparation of the extracts, the performance of the bioassay and the calculation of the IC \(_{50}\) values.

CONFLICTS OF INTERESTS

The authors have no conflicts of financial or personal interests with any other organizations or people.

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