Hypoglycemic Effect of Ocimum Lamiifolium in Alloxan Induced Diabetic Mice

ARTICLE · JANUARY 2016

15 AUTHORS, INCLUDING:

Festus Wambua
Kenyatta University
11 PUBLICATIONS 1 CITATION

Dorothy Wavinya Nyamai
Kenyatta University
19 PUBLICATIONS 3 CITATIONS

Phillip Ogola
Kenyatta University
12 PUBLICATIONS 1 CITATION

Mathew Piero Ngugi
Kenyatta University
67 PUBLICATIONS 61 CITATIONS

All in-text references underlined in blue are linked to publications on ResearchGate, letting you access and read them immediately. Available from: Hibert Rachuonyo Opinde
Retrieved on: 11 February 2016
Hypoglycemic Effect of Ocimum Lamiifolium in Alloxan Induced Diabetic Mice

Arika WM*, Rachuonyo HO, Muchori AN, Lagat RC, Mawia AM, Wambani JR, Wambua FK, Nyamai DW, Ogola PE, Kiboi NG, Ouko RO, Njagi SM, Muruthi CW, Ngugi MP and Njagi ENM

Department of Biochemistry and Biotechnology, School of Pure and Applied Sciences, Kenyatta University, P.O. Box 43844-00100, Nairobi, Kenya

Abstract

Plant remedies are the mainstay of treatment in underdeveloped regions owing to the side effects, unavailability and unaffordability of the conventional therapy. Among the traditional plants that have been used as an alternative therapy for diabetes mellitus is Ocimum lamiifolium, however, it has received limited scientific and medical evaluation to assess its efficacy. In this study, the in vivo hypoglycemic activity of aqueous leaf extracts of this plant was determined in male Swiss white albino mice. The antidiabetic activity was screened in alloxan induced diabetic mice using oral and intraperitoneal routes. The phytochemical composition was assessed using standard procedures. The extract showed hypoglycemic activity at dose levels of 25, 48.4, 93.5, 180.9, and 350 mg/kg body weight. The extracts contained tannins, sterols, flavonoids, saponins, terpenoids, and alkaloids. The observed hypoglycemic activity could be associated with the phytochemicals present in this plant extract.

Keywords: Diabetes Mellitus; Ocimum lamiifolium; Hypoglycemic activity; Antidiabetic; Phytochemical; Toxicity

Introduction

Diabetes mellitus (DM) is a major public health problem with an estimated global incidence of 382 million diabetics by 2014 and this number is expected to increase to over 592 million people in less than 25 years [1]. Diabetes mellitus (DM) is characterized by chronic hyperglycaemia resulting from defects in insulin metabolism and impaired function in carbohydrate, lipid and protein metabolism that leads to long-term complications [2]. DM is no longer a disease of rich developed countries [3]. Changes in dietary habits, obesity and physical inactivity are responsible for spreading this epidemic into the developing countries [3].

Diabetes mellitus may present with characteristic symptoms such as thirst, polyuria, blurring of vision, and weight loss [4]. In its most severe forms, ketoacidosis or a non-ketotic hyperosmolar state may develop and lead to stupor, coma and, in absence of effective treatment, death. Often symptoms are not severe, or may be absent, and consequently hyperglycaemia of sufficient degree to cause pathological and functional changes may be present for a long time before the diagnosis is made [4]. Among the complications associated with diabetes mellitus include microvascular complications which mainly affect the retina, kidney and peripheral nervous system and may progress to more serious complications, and macrovascular complications, mainly atherosclerosis, that may lead to cerebrovascular ischemia and stroke [3,4].

Several pathogenic processes are involved in the development of diabetes. These include processes which destroy the beta cells of the pancreas with consequent insulin deficiency (Type 1 diabetes), and others that result in resistance to insulin action or both (Type II diabetes) [4]. The abnormalities of carbohydrate, fat and protein metabolism are due to deficient action of insulin on target tissues resulting from insensitivity or lack of insulin [4].

Pharmacological treatment of diabetes mellitus is based on oral hypoglycaemic agents and insulin injection which have so many side effects, coupled with its high cost which is not affordable in poor economic communities [5]. Consequently, in rural parts of worldwide societies, traditional remedies from plant sources with minimal side effect are frequently employed to manage the disorder [5].

Ocimum lamiifolium is a perennial evergreen shrub having oblong, ovate green colored leaves (0.5-5 m), oppositely arranged having pubescent leaf surface, narrow at the base and deeply serrated (Plate 1) [6]. The genus Ocimum is cultivated for its extraordinary essential oil which display many therapeutic usages such as in medicinal application, herbs, culinary, perfume for herbal toiletries, aromatherapy treatment and as flavoring agent [6]. It has wide range of therapeutic effects like antimicrobial, antispasmodic, bactericide, carminative, anthelmintic, hepatoprotective, antiviral, larvicidal, remedy of coughs, colds, measles, abdominal pains, diarrhea, insect repellent, particularly

Plate 1: Ocimum lamiifolium (photograph taken in July 2013 at Kijauri Nyamira County)

*Corresponding author: Arika WM, Department of Biochemistry and Biotechnology, Kenyatta University, P.O. Box 43844-00100, Nairobi, Kenya. Tel: +254722863595, +254722873150; E-mail: wycliffearika@yahoo.com

Received December 02, 2015; Accepted January 13, 2016; Published January 18, 2016

Citation: Arika WM, Rachuonyo HO, Muchori AN, Lagat RC, Mawia AM, et al. (2016) Hypoglycemic Effect of Ocimum Lamiifolium in Alloxan Induced Diabetic Mice. Med Aromat Plants 5: 228. doi:10.4172/2167-0412.1000228

Copyright: © 2016 Arika WM, et al. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.
Materials and Methods

Study site

This study was undertaken at the Department of Biochemistry and Biotechnology, School of Pure and Applied Sciences, Kenyatta University from July 2013 to February 2015. Kenyatta University is 23 km from Nairobi off Thika Road.

Collection and preparation of the plant materials

The plant used in this study was collected from its native habitat on the basis of ethno-botanical information. It was collected with bio-conservation aspects in mind from Kijauri village Nyamira county Kenya. Information on the identity of the plant to collect, the precise locality where it grows, what part to collect, when curative potency is at maximum and the mode of preparation was provided by a traditional medical practitioner. For this study, the part of the plant collected was the leaves. Botanical identity of the plant was authenticated by an acknowledged authority in taxonomy and a voucher specimen deposited at the National Museums of Kenya Herbarium, Nairobi.

Leaves were collected while green and dried at room temperature away from direct sunlight for different periods of time depending on their succulence. The dried leaves were separately ground into fine powder by use of an electric mill. The powdered plant materials were kept at room temperature away from direct sunlight for 6 hours. The mixture was then freeze-dried for 48 hours in a Modulyo freeze dryer or gently nipped at the start of the experiment and repeated for 8-12 hours before use.

Preparation of the aqueous extracts

Each one hundred grams of the powdered plant material was extracted in 1 liter distilled water at 60°C for 6 hours. The mixture was then cooled and then decanted into dry clean conical flask through folded cotton gauze stuffed into a funnel. The decanted extract was then filtered using filter papers under vacuum pump. The filtrate was then freeze-dried for 48 hours in a Modulyo freeze dryer (Edward England). The freeze-dried powder was then weighed and stored in airtight container at -20°C until used for bioassay.

Experimental animals

The study used male Swiss White Albino mice (3-4 weeks old) that weighed 21-25 g with a mean weight of 23 g. These were bred in the animal house at the Department of Biochemistry and Biotechnology of Kenyatta University. The mice were housed at a temperature of 25°C with 12 hours/12 hours darkness photoperiod and fed on rodent pellets and water ad libitum. The experimental protocols and procedures used in this study were approved by the Ethics Committee for the Care and Use of Laboratory Animals of Kenyatta University, Kenya.

Induction of hyperglycemia

Hyperglycemia was induced experimentally by a single intraperitoneal administration of 186.9 mg/kg body weight of a freshly prepared 10% alloxan monohydrate (2,4,5,6 tetraoxypyrimidine; 5-6-dioxouracil) obtained from Sigma (Steinheim, Switzerland) [7].

Forty-eight hours after alloxan administration, blood glucose level was measured using a glucose.

Analyzer model (Hypogaurd, Woodbridge, England) with glucometer strips Mice with blood glucose levels above 2000 mg/L (>11.1 mmol/L) were considered diabetic and used in this study. Prior to initiation of this experiment, the animals were fasted for 8-12 hours [8] but allowed free access to water until the end of this experiment.

Experimental design

For either intraperitoneal or oral route of drug administration, the experimental mice were randomly divided into eight groups of five animals each. Group I consisted of normal mice either intraperitoneally or orally administered with 0.1 ml physiological saline; Group II consisted of alloxan induced diabetic mice either intraperitoneally or orally administered with 0.1 ml physiological saline; Group IIIa consisted of alloxan induced diabetic mice intraperitoneally administered with 1 IU/kg body weight in 0.1 ml physiological saline; Group IIIb consisted of alloxan induced diabetic mice orally administered with (3 mg/kg body weight) in 0.1 ml physiological saline; Group IV consisted of alloxan induced diabetic mice either intraperitoneally or orally administered with 25 mg/kg body weight in 0.1 ml physiological saline; Group V consisted of alloxan induced diabetic mice either intraperitoneally or orally administered with 48.4 mg/kg body weight in 0.1 ml physiological saline; Group VI consisted of alloxan induced diabetic mice either intraperitoneally or orally administered with 93.5 mg/kg body weight in 0.1 ml physiological saline; Group VII consisted of alloxan induced diabetic mice either intraperitoneally or orally administered with 180.9 mg/kg body weight in 1 ml physiological saline. Group VIII consisted of alloxan induced diabetic mice either intraperitoneally or orally administered with 350 mg/kg body weight in 1 ml physiological saline. 0.1 ml of either insulin or glibenclamide or the plant extract solution was administered either intraperitoneally or orally to each experimental mouse.

Blood sampling and blood glucose Determination

Blood sampling was done by sterilizing the tail with 10% alcohol and then nipping the tail at the start of the experiment and repeated after 1, 2, 3, 4, 6 and 24 hours. Bleeding was enhanced by gently "milking" the tail from the body towards the tip. After the operation, the tips of the tail were sterilized by swabbing with 70% ethanol. The blood glucose levels were determined with a glucose analyzer model (Hypogaurd, Woodbridge, England).

Qualitative phytochemical screening

Tannins were determined as follows; 2 ml of 5% FeCl3 was added to 2 ml aqueous extract of each sample. Yellow brown precipitate indicated presence of tannins [9]. Alkaloids were determined as follows; 1.5 ml of 1% HCL was added to 2 ml methanolic filtrates of samples. The solution was heated andsix drops of dragendroff reagent was added. Orange precipitate confirmed presence of alkaloids [9].

For saponins determination, aqueous extract of 2 g powder was made and subjected to frothing test. Frothing persistence indicated presence of saponins. Later the froth was mixed with few drops of olive oil. Formation of emulsion indicated presence of saponins [9]. For determination of flavonoids (shimodas test), 2 g material was extracted in 10 ml H2O, few drops of HCl followed by 0.5 g of zinc turnings were added. Formation of precipitate indicated presence of flavonoids [9].
added. Tubes were boiled for a few minutes formation of pink color indicated presence of flavonoids [9].

Terpenoids and sterols were determined as follows; the n-hexane was stirred with 2 g of each extract to remove most coloring materials. The residue was then extracted with 2 ml dichloromethane. The dichloromethane solution was dehydrated over anhydrous sodium sulphate. Then 2 ml of the dichloromethane portion was mixed with 0.5 ml acetic anhydride followed by 2 drops of concentrated sulphuric acid. A gradual appearance of green to blue color was indicative of sterols. Color change from pink to purple indicated the presence of terpenoids [10,11].

Results

Leaf extracts yielded a 8% light brown powder. Intraperitoneally administered aqueous leaf extracts of *O. lamifolium* decreased the blood glucose levels at all the five doses of 25, 48.4, 93.5, 180.9 and 350 mg/kg body weight (Table 1 and Figure 1). This occurred in two phases, in the first one hour the extract caused a steep decline in blood glucose levels, followed by a steady decline up to the seventh hour. After this, a gradual increase was recorded in the twenty fourth hour. However, the sugar levels were not reduced in a dose dependent manner.

In the first hour, the extracts lowered blood glucose levels to 67.8%, 59.5%, 54.4%, 65.7% and 53.9% for 25, 48.4, 93.5, 180.9 and 350 mg/kg body weight doses, respectively, compared to insulin treated diabetic mice whose blood sugar levels was lowered to 48.4% within the first hour. By the fourth hour, all the five doses (25, 48.4, 93.5, 180.9 and 350 mg/kg body weight) had lowered blood sugar levels to 37.8%, 27.0%, 27.5%, 37.2% and 26.2%, respectively, compared to insulin treated diabetic mice whose sugar levels was lowered to 36.3% within the same hour (Figure 1).

Orally administered aqueous leaf extracts of *O. lamifolium* also lowered blood glucose levels at all the five doses of 25, 48.4, 93.5, 180.9 and 350 mg/kg body weight (Table 2 and Figure 2), from the first hour to the twenty four hours in a dose independent manner. By the second hour the extract had lowered the blood glucose levels to 60.0%, 34.8%, 24.2%, 30.1% and 29.4% respectively.
showed that the oral and intraperitoneal uptake, enhanced transport of blood glucose to peripheral tissue and the of the insulin receptors [23]. The plants antihyperglycemic action may be the stimulation of β cells and subsequent release of insulin and activation of the insulin receptors [24].

Table 3 shows qualitative phytochemical composition of aqueous extracts of Ocimum lamiifolium. Results show that the plant extracts contained alkaloids, steroids, terpenoids, flavonoids, tannins and saponins.

| Phytochemicals | Ocimum lamiifolium |
|----------------|--------------------|
| Alkaloids      | +                  |
| Sterols        | +                  |
| Terpenoids     | +                  |
| Saponins       | +                  |
| Tannins        | +                  |
| Flavonoids     | +                  |

The blood glucose lowering effect of this plant extracts may be attributed to the presence of saponins, flavonoids, tannins, alkaloids, terpenoids and sterols that have been associated with hypoglycemic activity [25]. The presence of flavonoids, sterols and saponins has been previously reported in ethanolic fruit extracts of L. camara Linn which demonstrated hypoglycemic activity in streptozotocin induced diabetic male wistar rats [18]. Saponin fraction isolated from Momordica charantia reduced blood glucose levels and increased insulin secretion and glycogen synthesis in alloxan induced diabetic mice [28]. The alkaloid 1-eephedrine promotes the regeneration of pancreas islets following destruction of the beta cells, hence restores the secretion of insulin, and thus corrects hyperglycemia [27]. Intraperitoneally administered alkaloids isolated from leaves of Acanthus montanus at doses of 100, 200 and 400 mg/kg body weight showed hypoglycemic action in alloxan-induced diabetic rats [29]. The aqueous leaf extracts of the same plant contained tannins that are known to have hypoglycemic activity [30]. Condensed tannins extracted from some Kenyan foods showed antihyperglycemic action due to inhibition of α-amylase and α-glucosidase enzymes [31]. Terpenoids are very popular among patients with high blood pressure and diabetes because they help to reduce diastolic blood pressure and lower the sugar level in blood [2]. Due to the presence of terpenoids, the leaves and seeds of E. officinalis are used in the treatment of diabetes [32].

That the aqueous leave extracts of Ocimum lamiifolium in both oral and intraperitoneal routes the sugar levels started rising from the seventh hour in all dosage levels may have been due to the extracts having a short half-life or the extracts may have been prone to fast hepatic metabolism and renal clearance [5].

The blood glucose lowering effect of this plant extracts may be attributed to the presence of saponins, flavonoids, tannins, alkaloids, terpenoids and sterols that have been associated with hypoglycemic activity [27]. The presence of flavonoids, sterols and saponins has been previously reported in ethanolic fruit extracts of L. camara Linn which demonstrated hypoglycemic activity in streptozotocin induced diabetic male wistar rats [18]. Saponin fraction isolated from Momordica charantia reduced blood glucose levels and increased insulin secretion and glycogen synthesis in alloxan induced diabetic mice [28]. The alkaloid 1-eephedrine promotes the regeneration of pancreas islets following destruction of the beta cells, hence restores the secretion of insulin, and thus corrects hyperglycemia [27]. Intraperitoneally administered alkaloids isolated from leaves of Acanthus montanus at doses of 100, 200 and 400 mg/kg body weight showed hypoglycemic action in alloxan-induced diabetic rats [29]. The aqueous leaf extracts of the same plant contained tannins that are known to have hypoglycemic activity [30]. Condensed tannins extracted from some Kenyan foods showed antihyperglycemic action due to inhibition of α-amylase and α-glucosidase enzymes [31]. Terpenoids are very popular among patients with high blood pressure and diabetes because they help to reduce diastolic blood pressure and lower the sugar level in blood [2]. Due to the presence of terpenoids, the leaves and seeds of E. officinalis are used in the treatment of diabetes [32].

The present observation provide evidence that aqueous leaf extract of Ocimum lamiifolium exhibited antidiabetic activity on experimental alloxan induced diabetic mice when therapeutic doses were administered through intraperitoneal and oral routes. This effect might be due to the presence of phytochemicals such as saponins, flavonoids, tannins, alkaloids, terpenoids and sterols which could act synergically or independently in enhancing the hypoglycemic activity of the aqueous leaf extracts of Ocimum lamiifolium. However, further, comprehensive chemical and pharmacological investigation should be carried out to isolate the active compound and appropriate elucidation of its mechanism.

References
1. International Diabetes Federation (2013) IDF Diabetes Atlas. 6th Edn.
2. Piero NM, Kimuni NS, Ngerwana JNJ, Orinda GO, Njagi JM, et al. (2015) Antidiabetic and Safety of Lantana rhodesiensis in Alloxan Induced Diabetic Rats. J Develop Drugs 4: 129.
3. Wild S, Roglic G, Green A, Sicree R, King H (2004) Global prevalence of diabetes: estimates for the year 2000 and projections for 2030. Diabetes Care 27: 1047-1053.
4. Piero NM, Elid NN, Susan KN, George OQ, David NJMM, et al. (2015) In Vivo Antidiabetic Activity and Safety In Rats of Cissampelos pareira Traditionally Used In The Management of Diabetes Mellitus In Embu County, Kenya. Journal of Drug Metabolism & Toxicology 6:184.
5. Arika WM, Abdirahman YA, Mawia MM, Wambua KF, Nyamai DM, et al. (2015) Hypoglycemic Effect of Lippia javanica in Alloxan Induced Diabetic Mice. J. Diabetes Metab 6: 624.
6. Kashyap CP, Ranjeet K, Vikrant A, Vipin K (2011) Therapeutic Potency of Ocimum KilimandscharicumGuerke-A Review. Global Journal of Pharmacology 5: 191-200.
7. Szekuleski T (2001) The mechanism of alloxan and streptozotocin action in B cells of the rat pancreas. Physiol Res 50: 537-546.
Increased global visibility of articles through worldwide distribution and indexing

Special issues on the current trends of scientific research

50,000 Editorial team

Rapid review process

700 Open Access Journals

Better discount for your subsequent articles

Authors, Reviewers and Editors rewarded with online Scientific Credits

Sharing Option: Social Networking Enabled

Showcasing recent research output in a timely and updated manner

Submit your manuscript at: http://www.omicsonline.org/submission

Citation: Arika WM, Rachuonyo HO, Muchori AN, Lagat RC, Mawia AM, et al. (2016) Hypoglycemic Effect of Ocimum Lamifolium in Alloxan Induced Diabetic Mice. Med Aromat Plants 5: 228. doi:10.4172/2167-0412.1000228

OMICS International: Publication Benefits & Features

Unique features:

• Increased global visibility of articles through worldwide distribution and indexing

• Showcasing recent research output in a timely and updated manner

• Special issues on the current trends of scientific research

Special features:

• 700 Open Access Journals

• 50,000 Editorial team

• Rapid review process

• Quality and quick editorial review and publication processing

• Indexing at PubMed [partial], Scopus, EBSCO, Index Copernicus, Google Scholar etc.

• Sharing Option: Social Networking Enabled

• Authors, Reviewers and Editors rewarded with online Scientific Credits

• Better discount for your subsequent articles

Med Aromat Plants ISSN: 2167-0412 MAP, an open access journal Volume 5 • Issue 2 • 1000228

Citation: Arika WM, Rachuonyo HO, Muchori AN, Lagat RC, Mawia AM, et al. (2016) Hypoglycemic Effect of Ocimum Lamifolium in Alloxan Induced Diabetic Mice. Med Aromat Plants 5: 228. doi:10.4172/2167-0412.1000228

8. Karau GM, Njagi ENM, Machocho AK, Wangai LN, Kamau PN (2012) Hypoglycemic Activity of Aqueous and Ethylacetate Leaf and Stem Bark Extracts of Pappea Capensis in Alloxan-Induced Diabetic BALB/C Mice. British Journal of Pharmacology and Toxicology 3: 251-258.

9. Rasool R, Ganal BA, Akbar S, Kamili AN, Masood A (2010) Phytochemical screening of Prunella vulgaris L. - an important medicinal plant of Kashmir. Pak J Pharm Sci 23: 399-402.

10. Houghton PJ, Raman A (1998) Laboratory Handbook for the Fractionation of Natural extracts. Chapman and Hall 154-187.

11. Hosseinzadeh H, Younesi HM (2002) Antinoceptive and anti-inflammatory effects of Crocus sativus L. stigma and petal extracts in mice. BMC Pharmacol 2: 7.

12. Ngugi MP, Njagi JM, Kibiti CM, Miriti PM (2012) Pharmacological Management of Diabetes Mellitus. Biochemical and Pharmaceutical Research 1: 375-381.

13. Abdirahman YA, Juma KK, Makori WA, Agyuino DS, Ngugi MP, et al. (2015) Blood Glucose Lowering Effect and Safety of the Aqueous Leaf Extracts of Zania Africana. Pharmaceutica Analytica Acta 6:422.

14. Wilson GL, Leiter EH (1990) Streptozotocin interactions with pancreatic beta cells and the induction of insulin-dependent diabetes. Curr Top Microbiol Immunol 156: 27-54.

15. Bartosikova L, Necas J, Suchy V (2003) Monitoring of antioxidative effect of morine in alloxan-induced diabetes mellitus in the laboratory rat. Acta Vet Brno 72: 191-200.

16. Munugi NJ, Ngugi MP, Kibiti CM, Ngeranwa NJJ, Njagi ENM, et al. (2012) Evaluation of Antidiabetic effects of Kleinia squarrosa on alloxanized diabetic mice. Asian Journal of Biochemical and Pharmaceutical Research 2: 7.

17. Jannu V, Vishal DS, Babu VR, Harisha B, Reddy DRCS (2011) Antidiabetic activity of hydro-alcoholic extract of Cissampelos pareira Linn. leaves in streptozotocin-induced diabetic rats. Int J Pharm Tech 3: 3601-3611.

18. Venkatachalum T, Kumar VK, Selvi PK, Maske AO, Anbarasan V, et al. (2011) Antidiabetic activity of Lantana camara Linn.hemoglobin fruits in normal and streptozocin induced diabetic rats. J Pharm Res 4: 1550-1552.

19. al-Shamaony L, al-Khazraji SM, Twaij HA (1994) Hypoglycaemic effect of Artemisia herba alba. It. Effect of a valuable extract on some blood parameters in diabetic animals. J Ethnopharmacol 43: 167-171.

20. Abdel-Hassan IA, Abdel-Barry JA, Mohammeda TS (2000) The hypoglycaemic and antihyperglycaemic effect of Citrullus colocynthis fruit aqueous extract in normal and alloxan diabetic rabbits. Journal of Ethnopharmacology 71: 325-330.

21. Aguijc JC, Obi CI, Gans SS, Igweh AG (2000) Hypoglycemic activity of Ocimum gratissimum in rats. Filoterapia 71: 444-446.

22. Egesie UG, Adelaiye AB, Ibu JO, Egesie OJ (2006) Safety and hypoglycaemic properties of aqueous leaf extract of Ocimum gratissimum in streptozotocin induced diabetic rats. Niger J Physiol Sci 21: 31-35.

23. Mukundi MJ, Mwaniki NEN, Piero NM, Murugi NJ, Daniel AS, et al. (2015) In Vivo Anti-diabetic Effects of Aqueous Leaf Extracts of Rhoicissus tridentata in Alloxan Induced Diabetic Mice. J Develop Drugs 4: 131.

24. Piero NM, Njagi MJ, Kibiti MC, Ngeranwa NJ, Njagi NE, et al. (2012) Herbal Management of Diabetes Mellitus: A Rapidly Expanding Research Avenue. International Journal of Current Pharmaceutical Research 4.

25. Abdirahman YA, Juma KK, Mukundi MJ, Giashi SM, Agyuino DS (2015) The Hypoglycemic Activity and Safety of Aqueous Stem Bark Extracts of Acacia nilotica. Journal of Drug Metabolism Toxicology 6: 189-198.

26. Njagi JM (2011) Hypoglycemic effects of some Kenyan plants used traditionally in the management of diabetes mellitus in Gachoka division, Mbeere district (Doctoral dissertation).

27. Middleton E Jr, Kandaswami C, Theoharides TC (2000) The effects of plant flavonoids on mammalian cells: implications for inflammation, heart disease, and cancer. Pharmacol Rev 52: 673-751.

28. Han C, Hui Q, Wang Y (2008) Hypoglycaemic activity of saponin fraction extracted from Momordica charantia in PEG/salt aqueous two-phase systems. Nat Prod Res 22: 1112-1119.

29. Odoh UE, Ezugwu CO (2012) Anti-Diabetic and Toxicological Studies of The Alkaloids of Acanthus montanus (Acanthaceae) Leaf. Planta Medica 78.

30. Liu X, Kim JK, Li Y, Li J, Liu F, et al. (2005) Tannic acid stimulates glucose transport and inhibits adipocyte differentiation in 3T3-L1 cells. J Nutr 135: 165-171.

31. Kunyanga CN, Imungi JK, Okoth M, Momanyi C, Biesalski HK, et al. (2011) Antioxidant and anti diabetic properties of condensed tannins in acetonic extract of selected raw and processed indigenous food ingredients from Kenya. J Food Sci 76: C560-C567.

32. Treadway L (1994) Amla: Traditional food and medicine. J Amer Bot Coun 31: 26.