RESEARCH ARTICLE

In vitro antioxidant, $\alpha$-amylase and $\alpha$-glucosidase activities of methanol extracts from three Momordica species

Akinwunmi Olubunmi Adenike

Abstract

Antioxidant based drug preparations are used in the prevention and management of complex diseases which include atherosclerosis, stroke, diabetes, Alzheimer’s disease and cancer. Diabetes mellitus is a metabolic disorder of glucose metabolism. The management of blood glucose level is the hallmark in the treatment of this ailment, which may be achieved through the use of oral hypoglycemic drugs such as biguanides, insulin secretagogues, and $\alpha$-amylase and glucosidase inhibitors. Although several biological activities had been reported for Momordicafoetida and Momordicacharantia; it appears there is limited information on the biological activity of Momordicacissoides. The purpose of this study is to compare the antioxidant, $\alpha$-amylase and $\alpha$-glucosidase inhibitory activities of Momordicafoetida (M1), Momordicafoetida (M2), and Momordicacissoides (M3) to establish a chemotaxonomic relationship between them. The antioxidant activities measured by DPPH scavenging properties, metal ion chelation, hydrogen peroxide scavenging and ABTS revealed that M. foetida had the highest inhibition potential, followed by M.charantia and the least being M.cissoides. In contrast, the antioxidant activities measured by FRAP, the total phenolic content, flavonoids and tannins revealed that M. cissoides had the best antioxidant potential, while M. foetida had the least activity. The comparative $\alpha$-amylase and glucosidase inhibitory studies performed demonstrated that the extracts of M.cissoides had the highest inhibitory potentials. Thus, the plant can be used in the management of diabetes.

Keywords: Mcissoides; amylase; glucosidase; antioxidants; diabetes

Introduction

Free radicals, which belong to a group of reactive oxygen species (ROS), are produced through endogenous source, that is, the human body itself, and exogenous sources such as tobacco smoke, burning of fossil fuels, and ozone. The imbalance between the production of ROS and the activity of the antioxidant defences is referred to as oxidative stress [1]. The preventive or protective effects of herbs or spices against the harmful consequences of oxidative stress are due to the existence of naturally obtainable antioxidants in them [2]. Antioxidant based drug preparations are used in the exclusion and controlling of complex diseases which include atherosclerosis, stroke, diabetes, Alzheimer’s disease, and cancer [2, 3].

Diabetes mellitus (DM) has repeatedly been described as a metabolic disorder characterized by hyperglycemia which develops as an upshot of defects in insulin secretion, action, or both [4]. It is one of the communal metabolic problems with micro- and macrovascular complications that results in significant morbidity and mortality. Diabetes mellitus is also one of the five main causes of death in the world. In contemporary medicine no satisfactory effective therapy is still obtainable to cure diabetes mellitus. There is a growing demand by patients to use natural products with antidiabetic activity due to side effects associated with the use of insulin and oral hypoglycemic...
agents. Many traditional medicinal plants have been reported to have hypoglycemic activity [5].

*Momordica* is a genus of about 60 species of annual or perennial climbers that are herbaceous or rarely small shrubs belonging to the family cucurbitaceae. They are natives of tropical and subtropical Africa, Asia and Australia. Most species yield floral oils and are visited by specialist pollinators in the aphid tribe *ctenoplectrini*. A molecular phylogeny that includes all species is available [6, 7].

*Momordica foetida* Schumach. et Thonn. from the *cucurbitaceae* family, is a medicinal plant, widely distributed in tropical Africa, South and West tropical Africa. The plant has both male and female flowers. *Momordica foetida* has been used in the treatment of malaria, hypertension, peptic ulcers, diabetes mellitus, and as a purgative. Curcurbitane triterpenoids and polyphenolic compounds have been isolated from the leaf extracts while alkaloids and glycosides were obtained from the whole plant extracts [8].

*Momordica Charantia* (bitter melon or bitter gourd) is a flowering vine also in *cucurbitaceae* family which is widely cultivated in Asia, India, East Africa and South America. The plant is used as a natural remedy for diabetes, topically for sores, wounds and infections. It is also used to expel worms and parasites; as an emmenagogue; and as antiviral for measles, hepatitis and feverish conditions. The plant is also being used to induce abortion. Several alkaloids, triterpenoids and glycosides have been isolated from the plant [9, 10].

*Momordica cissoide* Linn. is a plant used in traditional folk medicine by many African countries for the treatment of several illnesses like; epilepsy, headache, madness and gonorrhoea. The plant has been reported for its anticonvulsant and antioxidant activity [11]. There are so many species of *momordica* but it appears that the information on *Momordica cissoide* is limited.

Several studies have shown the antidiabetic activity of *M. foetida* and *M. Charantia* [8, 10, 12], no erstwhile report has been given on the antidiabetic potential of *M. cissoide*. The earlier report of the comparative phytochemical screening of the three medicinal plants which indicated that *M. cissoide* is rich in saponins, phenols and tannins was documented by Akinwumi [13], prompted this research. This might also be useful to ascertain their chemotaxonomic relationship. Thus, this research is a follow up to the previous one. It is aimed at evaluating the effect of the *M. foetida*, *M. Charantia* and *M. cissoide* for antioxidant, α-amylase and α-glucosidase activities.

### Material and methods

#### Sample preparation

The Fresh leaves of *M. foetida*, *M. charantia* and *M. cissoide* were collected from the Sawmill area, Ikere road, Ado- Ekiti, Ekiti State, Nigeria. The plants were identified by Mr. Omotayo at the Herbarium section of the Department of Plant Science and Biotechnology, Ekiti State University, Ado-Ekiti. The leave samples were air dried for three weeks at room temperature and ground into powder using an electric blender. The resultant powder were soaked in methanol for 72 hrs, filtered and concentrated at 40°C using rotary evaporator. The methanol extracts were then stored at - 4°C pending analysis.

#### DPPH Radical-Scavenging Activity Assay

Free radical scavenging activity of the leaves of *Momordica* plant extracts were measured according to the method of Wickramarate et al [14], with slight modifications. This assay was based on the fact that DPPH would be reduced to hydrazine. 0.2% solution of DPPH was added to various concentrations of extracts ranging from 10 to 50 µg /ml in a 96-well plate. The solution was incubated at room temperature in the dark for 30 minutes, thereafter; the absorbance was measured at 490 nm using a microplate reader. The diluting solvent was used as a blank and the scavenging activity was calculated as follows:

\[
\text{% inhibition} = \frac{A_{490 \text{ of blank}} - A_{490 \text{ of sample}}}{A_{490 \text{ of blank}}} \times 100
\]

#### Hydrogen Peroxide Scavenging

40mM solution of H₂O₂ was prepared in 0.1M phosphate buffer (pH 7.4). Various concentrations (10 -50 µg /ml) of the extracts were added to 0.6ml H₂O₂ solution and the total volume was made up to 3ml. The absorbance of the reaction mixture was then measured at 230nm using a spectrophotometer. Phosphate buffer was used as a blank and the extent of H₂O₂ scavenging of the plant extracts was calculated as:

\[
\text{% inhibition} = \frac{A_{490 \text{ of blank}} - A_{490 \text{ of sample}}}{A_{490 \text{ of blank}}} \times 100
\]

#### Metal chelating activity assay

0.16 ml of deionized water and 0.005 ml of 2 mM FeCl₂ was added to 0.05 ml of extract at different concentrations (10-50 µg /ml). 0.01 ml of 5 mM ferrozine was added after 30 s. The absorbance of the resultant Fe²⁺ –Ferrozine complex formed from the reaction above was measured at 562 nm after 10 minutes at the room temperature. The chelating activity of the extract for Fe²⁺ was calculated as

\[
\text{Chelating rate (\\%)} = \frac{(A_0 - A_1)}{A_0} \times 100
\]

Where A₀ represents the absorbance of the control blank without extract and A₁ was the absorbance of the extract [16].
**Total phenolic content determination**
The total phenolic content of the plant samples were determined according to the method described by Nagulendran et al [17] with slight modifications. 0.05 ml of the plant extract with concentration of 1 mg/ml was added to 0.05 ml of Folin-Ciocalteu reagent, after 3 minutes, 0.1 ml of 2% Na₂CO₃ was added. Afterwards, the mixture was shaken for 2 h at 28 °C, and then absorbance was measured at 760 nm. Quercetin was used as the standard.

**Tannin determination**
50 ml of distilled water was added to about 500 mg of the sample and the mixture shaken for 1 hour using a mechanical shaker. This was filtered into a 50 ml standard flask and made up to the mark with distilled water. 0.1 ml of the filtrate was mixed with 0.06 ml of 0.1M FeCl₃ in 0.1N HCl and 0.008M KFe(CN)₆. The absorbance was afterwards measured using a spectrophotometer at 605 nm within 10 minutes. The absorbance of the blank was also measured at the same wavelength. Gallic acid was used as a standard [18].

**Determination of 2,2-Azinobis (3-ethylbenzo-thiazoline-6-sulfonate (ABTS)radical scavenging ability**
The ABTS⁺ scavenging ability of the extracts was quantified according to the method of Re et al [19]. The ABTS⁺ radical was generated by reacting a 7 mM 1⁻¹ ABTS aqueous solution with 2.45 mM 1⁻¹ K₂ S₂ O₈ in the dark for 16 h. The absorbance was adjusted to 0.700 with ethanol at 734 nm. 0.05 ml of appropriate dilution of the extract was added to 0.15 ml ABTS⁺ solution and the absorbance were measured at 734 nm after 15 minutes.

**Reducing Power Assay**
The reducing power assay was carried out by the method of Nagulendran et al [17]. 2.5ml of the extract solution was mixed with 2.5 ml of 0.2M sodium phosphate buffer and 2.5 ml of 1% potassium ferricyanide. The resultant mixture was then incubated at 50 °C for 20 minutes, after which a 2.5 ml of 100 mg/l trichloroacetic acid solution was added. The mixture was centrifuged at 650 rpm for 10 minutes. 5 ml of the supernatant was mixed with 5 ml of distilled water and 1 ml of 0.1% ferric chloride solution. The absorbance was determined at 700 nm.

**Total Flavonoid**
The total flavonoid content was measured by the aluminium chloride colorimetric assay. 0.01 ml of extracts or standard solution containing 500µg/ml of quercetin was added to 10 ml standard flask containing 0.04 ml of distilled water. To the above mixture, 0.03 ml of 5% NaNO₂ was added, after 5 minutes, 0.03 ml of 10% AlCl₃ was then added. At the 6th min, 0.02 ml of 1 M NaOH was added and the total volume made up to 0.2 ml with distilled water. The solution was properly mixed and the absorbance measured against the blank at 510 nm. Total flavonoid content of the extract was expressed as percentage of quercetin equivalent per 100 g sample [17].

**α- amylase inhibition activity**
The inhibition of alpha amylase activity was carried out using an amended procedure described by Kazeem et al [20]. 20 µl of sample at concentrations 10-50 µg/ml was reacted with 140 µl 0.1M sodium phosphate (pH 6.8) and 10 µl 0.02U/ml amylase prepared in enzyme. The mixture was incubated at room temperature for 15 minutes. 10 µl of 1%w/v starch solution was added and incubated at room temperature for 15 minutes. 10 µl of 96mM dinitrosalicyclic (DNS) acid was added to the resultant mixture above and the plate incubated in boiling water for 5 minutes. The absorbance was recorded at 540 nm using microplate reader, while the % inhibition of α-amylase enzyme was calculated using the formula: % Inhibition = \( \frac{A_{control} - A_{sample}}{A_{control}} \times 100 \)

**α-glucosidase inhibition activity**
The inhibitory effect of the *M. species* extracts on α-glucosidase activity was determined according to the chromogenic method described by Kazeem et al [20], with slight modifications. Concisely, 5 units of α-glucosidase were pre-incubated with 10-50 µg/ml of the *M. species* extracts for 15 minutes. 3 mM Paranitrophenylglucopyranoside (PNPG ) dissolved in 20 mM phosphate buffer (pH 6.9) was added to start the reaction. The reaction mixture was further incubated at 37°C for 20 minutes and then stopped via the addition of 2 ml of 0.1 M Na₂CO₃. The α-glucosidase activity was determined by measuring the yellow colored p-nitrophenol released from PNPG at 400 nm. Each test was performed in triplicates and the mean absorbance was used to calculate % α-glucosidase inhibition using the formula:

% α-glucosidase inhibition = \( \frac{A_0 - A_1}{A_0} \times 100 \)

where A₀ was the absorbance of the blank control without extract and A₁ was the absorbance in the presence of the extract.

**Statistical Analysis**
Data were represented as mean ± SEM of at least three independent experiments. The data were also analysed using Prism Graph Pad software (San Diego, USA).
Results

DPPH radical scavenging activity

The DPPH radical scavenging activities of M1-M3 extracts showed IC\textsubscript{50} value > 50 µg/ml (Fig. 1A, Table 1). The highest activity was observed in M2 extract at 50 µg/ml with 22.77±0.22 % inhibition and the lowest in M3 (17.94±0.12). At the same concentration, ascorbic acid, the positive control had the % inhibition (96.7±1.03) with IC\textsubscript{50} 19.2 µg/ml.

Hydrogen Peroxide Scavenging

As revealed in Fig. 1B, hydrogen peroxide scavenging activity showed that M2 had the highest % inhibition (16.15±0.07) and the lowest % inhibition was exhibited by M3 (13.82±0.84). The IC\textsubscript{50} values for M1-3 were > 50 µg/ml while that of ascorbic acid used as the standard was 1.23 µg/ml (Table 1).

Metal ion Chelation activity

The result of the metal ion chelation activity showed that at 50 µg/ml, M2 had the highest % inhibition (20.25±0.20) and the lowest % inhibition in M3 (12.93±0.26) (Fig.1C). Similarly at the same concentration, EDTA used as control had % inhibition (99.01±0.73) with IC\textsubscript{50} 17.8 µg/ml, Table 1.

Total phenolic content, tannin, ABTS (TEAC), FRAP and flavonoid content.

The total phenolic content (TPC) and tannin is expressed as Gallic acid equivalents in mg/100g of extract (Table 2). M3 had the highest phenolic content (38.50±1.73) while M2 had the least (16.38±1.15). The result of the tannin content followed a similar pattern. M3 had the highest value (81.94±3.47) while M2 (27.60±0.87) had the lowest.

The ABTS (TEAC) result showed that M2 had the highest scavenging ability (11.96±1.28) mg/100g while the lowest was observed in M3 (8.55±0.43) mg/100g (Table 2).

The FRAP assay is expressed as AAEmg/100g as shown in Table 2. M3 had the highest reducing capability with 1020.00±5.00 while M2 646.25±3.75 had the lowest value.

The result of the flavonoid content of the plant extract as expressed in QEmg/100g showed that it ranged between 49.2±8.46 – 111.7±4.10. M3 had the highest amount of flavonoid while M2 had the least content.

Alpha-amylase and glucosidase inhibition activity

Alpha-amylase inhibitory potential of the methanolic extracts obtained from the three Momordica species; *M. charantia* (M1), *M. foetida* (M2) and *M. cissoides* (M3) was determined (Fig.
Table 2 Other antioxidant parameters (mean ± SEM) measured in three different extracts of leaves of Momordica species

| Extract | Phenolics (GAE mg/100g) | Tannin (GAE mg/100g) | ABTS (TEAC) (mg/100g) | FRAP (AAE mg/100g) | Flavonoids (QAE mg/100g) |
|---------|-------------------------|----------------------|------------------------|---------------------|--------------------------|
| M1      | 23.1 ± 4.04             | 74.8 ± 4.55          | 8.55 ± 0.43            | 821.3 ± 1.25        | 77.5 ± 1.92              |
| M2      | 16.4 ± 1.15             | 27.6 ± 0.87          | 11.96 ± 1.28           | 661.3 ± 3.75        | 49.1 ± 2.46              |
| M3      | 38.5 ± 1.73             | 81.9 ± 1.53          | 7.56 ± 0.28            | 990.0 ± 1.36        | 111.1 ± 3.10             |

M. charantia (M1), M. foetida (M2) and M. cissoides (M3).

2A), at the highest concentration 50 µg/ml M3 had the highest % inhibition (31.45 ± 1.04) while M2 had the lowest (21.66 ± 0.46). The IC₅₀ values were calculated (Table 3). M1-M3 had IC₅₀ values > 50 µg/ml. The standard positive control Acarbose showed an IC₅₀ of 45.2 µg/ml and the maximum % inhibition of 55.89 ± 0.43. Similarly, the result of the α-glucosidase inhibitory potential of M1, M2 and M3 (Fig. 2B, Table 3) showed that at 50 µg/ml, the maximum dose, M3 had the highest % inhibition (24.11 ± 0.43) while M2 had the lowest (15.67 ± 0.64). M1-M3 IC₅₀ values were > 50 µg/ml. Acarbose, the control had the % inhibition of 52.72 ± 0.31, IC₅₀ value 46.2 µg/ml.

![Figure 2](image)

Discussion

There is a growing trend in the screening of medicinal plants for antidiabetic activity. This has also necessitated the discovery of new effective drugs for the disease. Although the leaf extracts of M. charantia and M. foetida have exhibited antidiabetic activities [8, 10, 12]. This study would be the first report on detailed comparative study of antioxidant, α-amylase and α-glucosidase inhibitory activity study on the three Momordica species. It is also the first report of α-amylase and α-glucosidase inhibitory activity on M. cissoides to the best of our knowledge.

The comparative α-amylase and glucosidase inhibitory studies performed demonstrated that the extracts of M. cissoides had the highest inhibitory potentials. The inhibitory activity may likely be due to the greater number of phytochemicals present in the plant as reported by Akinwumi [13]. Previous report on α-amylase and α-glucosidase inhibitors isolated from medicinal plants suggest that several prospective inhibitors belong to flavonoid class [20, 21]. It may be necessary to isolate the biologically active compounds responsible for the activity.

It has been predicted that diabetic complications occur as a result of the oxidative stress due to the formation of free radicals with the glucose oxidation and the subsequent oxidative degradation of glycated proteins. Consequently, the use of antioxidants alongside with anti-diabetic drugs is frequently recommended to evade such complications [14]. The antioxidant activity of a compound has been attributed to various mechanisms, namely; prevention of chain initiation, binding of transition metal ion catalysts, decomposition of peroxides, prevention of continued hydrogen abstraction, reductive capacity and radical scavenging ability [22].
Generally, all the extracts do possess mild antioxidant activities. The antioxidant activities measured by DPPH scavenging properties, metal ion chelation, hydrogen peroxide scavenging and ABTS revealed that M. foetida had the highest inhibition potential, followed by M. charantia and the least being M. cissoides. In contrast, the antioxidant activities measured by FRAP, the total phenolic content, flavonoids and tannins revealed that M. cissoides had the best antioxidant potential, while M. foetida had the least activity. This is fully in agreement with the phytochemical analysis result as reported by Akinwumi [13], which clearly indicated that M. cissoides is very rich in phenols, saponin and tannin. The least activity observed in M. foetida could be as a result of absence of flavonoid in the extract. Other phytochemicals like; tannin and phenols were also present in small quantities when compared with M. cissoides.

Conclusions
This study demonstrates that the methanol extracts of M. charantia, M. foetida and M. cissoides has variable antioxidant activity that can be ascribed to variability in the concentration of various phytochemicals like; phenols, saponin, tannin and flavonoids. M. cissoides extract exhibited the best α-amylase and glucosidase inhibitory activity. Hence the leaves of M. cissoides have the potential to be used in the treatment of Type II diabetes mellitus. Furthermore, this study has opened opportunities for future research in the search for novel effective drugs for diabetes that possess both antioxidant and anti-diabetic activities.

References
[1] Krovnov S, Miurcov L, Mach L. Antioxidant activity and protecting health effects of common medicinal plants. Adv Food Nutr Res. 2012;67:75–139. Available from: DOI: 10.1016/B978-0-12-394598-3.00003-4.
[2] Khalaf NA, Shakya AK, Al-Othman A, El-Agbar Z, Farah H. Antioxidant activity of some common plants. Turk J of Biology. 2008;32(1):51–55.
[3] Ayeleso AO, Oguntibeju OO, Brooks NL. In vitro study on the antioxidant potentials of the leaves and fruits of Naultea latifolia. Sci. World J. 2014;8. Article ID 437081. Available from: 10.1155/2014/437081.
[4] Chawla A, Chawla R, Jaggi S. Microvascular and macrovascular complications in diabetes mellitus: Distinct or continuum? Indian J Endocr Metab. 2016;20(4):541–546. Available from: DOI:10.4103/2230-8210.183480.
[5] Ahmed MF, Kazim SM, Ghorii SS, Mejhabeen SS, Ahmed SR, Ali SM, et al. Antidiabetic activity of Vinca rosea extracts in alloxan-induced diabetic rats. Int J Endocrinol. 2010;Available from: 841090.DOI:10.1155/2010/841090.
[6] wikipedia. Momordica.; Available from: https://en.wikipedia.org/wiki/Momordica.
[7] H, Ss R. A three-genome phylogeny of Momordica (Cucurbitaceae) suggests seven returns from dioecy to monoecy and recent long-distance dispersal to Asia. Mol Phylogenet Evol. 2010;54(2). Available from: 553-560. PMID19686858.DOI:10.1016/j.ympev.2009.08.006.
[8] Acquaviva R, Giacomino D, Vanello C, Santangelo L, Sorrenti R, Barbagallo V, et al. -. Momordica foetida Schumach et Thonn Molecules. 2013;18(3):3241–3249. Available from: DOI:10.3390/molecules18033241.
[9] Joseph B, Jini D. Antidiabetic effects of Momordica charantia (bitter melon) and its medicinal potency. Asian Pac J Trop Dis. 2013;3(2). Available from: 93-102.DOI:10.1016/S2222-1808(13)60052-3.
[10] Anilakumar KR, Kumar GP, Ilaiyaraja N. Nutritional, pharmacological and medicinal properties of Momordica charantia. Int J Nutr And Food Sci. 2015;4(1). Available from: 73-83.DOI:10.11648/j.ijnfs.20150401.21.
[11] Ojong LJ, Abdou JP, Kandeda AK, Yaya A, Tchamgoue AD, Thokouah J. Anticonvulsant and in Vitro Antioxidant Activities of Momordica Cissoides L. (Cucurbitaceae). J App Pharm Sci. 2016;6(4). Available from: 117-123.DOI:10.7324/JAPS.2016.60416.
[12] Raza H, Ahmed I, John A, Sharma AK. Modulation of xenobiotic metabolism and oxidative stress in chronic streptozotocin-induced diabetic rats fed with Momordica charantia fruit extract. J Biochem Mol Toxicol. 2000;14:10711628–10711628.
[13] Akinwumi OA. Phytochemical screening and chemical analysis of methanic extracts of the leaves of three momordica species. FUW Trends in Science & Technology Journal. 2017;2(2):13–13.
[14] Wickramaratne MN, Punchihewa JC, Wickramaratne D. In-vitro alpha amylase inhibitory activity of the leaf extracts of Adenanthera pavonina. BMC Compl and Altern Med. 2016;Available from: 16:466.DOI10.1186/s12906-016-1452-y.
[15] Keser S, Celik S, Turkoglu S, Yilmaz O, Turkoglu I. Hydrogen peroxide radical scavenging and total antioxidant activity of hawthorn. Chemistry Journal. 2012;2(1):9–12.
[16] Dinis TC, Madeira VM, Almeida LM. Action of phenolic derivatives (acetaminophen, salicylate, and 5-aminosaliclyate) as inhibitors of membrane lipid peroxidation and as peroxy radical scavengers. Arch Biochem Biophys. 1994;315(1):7979394–7979394.
[17] Nagulendran KR, Velavan S, Mahesh R, Begum VH. In vitro antioxidant activity and total polyphenolic content of Cyperus rotundus rhizomes. E-Journal of Chem-
istry. 2007;4(3):440–449. Available from: 10.1155/2007/903496.

[18] Okwu DE, Iroabuchi F. Phytochemical composition and biological activities of Uvaria chamae and Clerodendron splendens. Journal of Chemistry. 2009;6(2):973–945.

[19] Re R, Pellegrini N, Proteggente A, Pannala A, Yang M, Rice-Evans C. Antioxidant activity applying an improved ABTS radical cation decolorization assay. Free Radic. Biol Med. 1999;26:10381194–10381194.

[20] Kazeem MI, Adamson JO, Ogunwande IA. Modes of inhibition of -amylase and -glucosidase by aqueous extract of Morinda lucida Benth leaf. BioMed ResInt. 2013;6. Available from: 10.1155/2013/527570.

[21] Kwon YI, Apostolidis E, Shetty K. Evaluation of pepper (Capsicum anuum) for management of diabetes and hypertension. J Food Biochem. 2007;31(3). Available from: 370-385.DOI:10.1111/j.1745-4514.2007.00120.x.

[22] Carocho M, Ferreira I. A review on antioxidants, prooxidants and related controversy: natural and synthetic compounds, screening and analysis methodologies and future perspectives. Food Chem Toxicol. 2013;Available from: 51:15-25.DOI:10.1016/j.fct.2012.09.021.