Trends in Applied Sciences Research

ISSN 1819-3579

Academic
Journals Inc.

www.academicjournals.com

OPEN ACCESS Trends in Applied Sciences Research

ISSN 1819-3579
DOI: 10.3923/tasr.2019.113.118

Research Article
Quantitative Phytochemical Analysis of *Annona muricata* and *Artocarpus heterophyllus* Leaves Using Gas Chromatography-flame Ionization Detector

[1]C.L. Onuah, [1]C.C. Chukwuma, [1]R. Ohanador, [1]C.N. Chukwu and [2]J. Iruolagbe

[1]Department of Biochemistry, Faculty of Science, University of Port Harcourt, P. M. B 5323, Port Harcourt, Nigeria
[2]Department of Pharmacology, Faculty of Basic Medical Sciences, University of Port Harcourt, P. M. B 5323, Port Harcourt, Nigeria

Abstract

Background and Objective: Phytochemicals are bioactive non-nutritive secondary metabolites found in different parts of plants. They have been effective in the treatment of diseases and infections. There has been an increase in the use of natural products due to their little or no side effects. *Annona muricata* (Soursop) and *Artocarpus heterophyllus* (Jackfruit) are tropical plants used in folk medicine in the treatment of different diseases and infection. Hence the quantitative phytochemical screening of the leaves of *Annona muricata* (Soursop) and *Artocarpus heterophyllus* (Jackfruit) were analyzed to ascertain the bioactive compounds present in them. **Materials and Methods:** The phytochemical content of the leaves of *Annona muricata* (Soursop) and *Artocarpus heterophyllus* (Jackfruit) were quantified using gas chromatography-flame ionization detector. **Results:** The result showed the presence of Sparteine, Anthocyanin, Sapogenin, Morphine, Phenol, Quinine, Ribalinidine, Ephedrine, Resveratrol, Catechin, Saponin, Oxalate and Quercertin in *Annona muricata* leaves while *Artocarpus heterophyllus* leaves contained Sparteine, Anthocyanin, Sapogenin, Morphine, Phenol, Glycitein, Quinine, Ribalinidine, Ephedrine, Resveratrol and Catechin at different concentrations. **Conclusion:** The quantitative phytochemical screening of the leaves of *A. muricata* and *A. heterophyllus* showed that both plants are rich in both alkaloids and flavonoids (phenolic compounds).

Key words: Phytochemical, phenolic, alkaloid, flavonoid, anti-oxidant, *Annona muricata*, *Artocarpus heterophylus*

Citation: C.L. Onuah, C.C. Chukwuma, R. Ohanador, C.N. Chukwu and J. Iruolagbe, 2019. Quantitative phytochemical analysis of *Annona muricata* and *Artocarpus heterophyllus* leaves using gas chromatography-flame ionization detector. Trends Applied Sci. Res., 14: 113-118.

Corresponding Author: C.L. Onuah, Department of Biochemistry, Faculty of Science, University of Port Harcourt, P. M. B 5323, Port Harcourt, Nigeria

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Phytochemicals are non-nutritive chemicals secreted by plants, which possess bioactive properties[1], they also serve as defence systems against pathogens and animals[2]. Different classes of phytochemicals exist, they include carbohydrates, lipids, phenolics, terpenoids and alkaloids and other nitrogen-containing compounds[3].

Phytochemicals play different roles in plant, they protect plants from harmful insects, microbes, ultraviolet (UV) rays and extreme temperatures. They also attract birds and insects that promote pollination, germination and seed dispersal[4]. Besides they provide colour to plants and also serve as a source of flavor to plants[5]. Besides the roles phytochemicals play in plants, they also play important roles in man and animals. Most phytochemicals possess antioxidant activities hence they help in cleaning up free radicals and also prevent diseases that manifest from reactive oxygen species (ROS)[6-8]. Phytochemicals prevent and ameliorate diseases such as diabetes, cancer, hyperlipidaemia, cardiovascular diseases, liver toxicity, Alzheimer, cataract, age related function decline, stroke and others.

Different phytochemicals that have been isolated from plants include alkaloids, saponins, glycosides, flavonoids, kaempferol, phytol, gallic acid, kolaviron and essential oils[9].

The *A. muricata* generally called graviola, guanabana[10] is a green leafy plant which belong to annonaceae family[11]. It is a fruit tree found mostly in the tropics and commonly cultivated in South America, Central America, Africa and Asia[12].

Every part of *A. muricata* has rich deposit of plant chemicals which have healing effects. These phytochemicals include; alkaloids, tannin, megastigmanes, flavonol, triglycerides, flavonoids, alkaloids, steroids, triterpenoid[13] and cyclopeptides[14]. Phytochemicals such as tannins, coumarins, stearic acid, myristique acid and ellagic acid have been identified in *A. muricata* leaves and stems[11].

In another, *A. muricata* pulp contains 6. 44 mg/100 g anthocyanin and 1. 90 mg/100 g of alkaloid[15] while methanol and aqueous extract of *A. muricata* showed the presence of cardiac glycosides, anthraquinones, phlobatannin and reducing sugars, respectively[16]. Compounds isolated from the leaves, fruits, seeds, pericarp, roots and stem of *A. muricate* have shown toxicity against cancer, they include annopentocin, cis-Annomuricin-D-one and Annocatalin[14].

The *A. heterophyllus* known as Jackfruit in English and Kanthal in Bangladesh is a fruit in the mulberry family known as Moraceae. It grows wildly in the tropics especially in India and Malaysia[17]. It is grown in the Central and eastern Africa and also in the Caribbean[18]. The leaves, fruits, seeds, barks, roots and the stem of *A. heterophyllus* are rich in isoflavons, niacin, saponin, lignans, flavonoids, alkaloids, glycosides, tannins, triterpenes[19], phenolic compounds[20], 'morin, dihydromorin, cynomacurin, artocarpin, isoartocarpin, cyloartocarpin, artocarpesin, artocarpetin, norartocarpetin, cycloartinone and artocarpanone[21]. Recently, a lot of interest has been focused on natural products especially those from plants. Plants are known to be rich in a wide range of bioactive chemicals which are used in the treatment of different kinds of diseases and infections. The *A. muricata* (Soursop) and *A. heterophyllus* (Jackfruit) leaves are one of such plants which are used especially in folk and Ayurveda medicine in the treatment of diseases. The *A. muricata* leaves have been effectively used locally in the treatment of diabetes while *A. hetrophyllus* has been used in the treatment of diabetes mellitus, convulsion/epilepsy and microbial infections[19]. The effectiveness of these plants in the treatment of different kinds of disease and infections can be attributed to their phytochemical contents, hence the knowledge of different bioactive compounds present in these plants may stand as a yardstick in pharmaceutical production of drugs.

MATERIALS AND METHODS

Gas chromatography-flame ionization detector (BUCK M910) was used for the quantification of the phytochemicals present in the plants.

Collection and identification of plants: The leaves of *A. muricata* were obtained from Abuja park of University of Port Harcourt while the leaves of *A. heterophyllus* were obtained from Ozuoba Obior/Akpo Local Government Area of Rivers state.

Plant material: *Artocarpus heterophyllus* and *Anonna muricate* were identified and confirmed botanically by Dr. Ekeke Chimezie of the Department of Plant Science and Biotechnology, University of Port Harcourt, Choba, Nigeria and the voucher specimen deposited at the herbarium of Department of Plant Science and Biotechnology, University of University of Port Harcourt, Nigeria.

Determination of quantitative phytochemical content of the plants

Extraction of the phytochemicals: About 1 g of each of the plant samples (*A. murcata* and *A. heterophyllus*) were added 15 mL of ethanol and 10 mL of 50% m/v potassium hydroxide. This was kept in a water bath for 60 min at a temperature of 60°C. The different extracts obtained were washed three times with 10 mL of 10% v/v ethanol aqueous solution, dried with anhydrous sodium sulphate and the

solvent was evaporated. Each of the sample extracts were solubilized in 1000 µL of pyridine, 200 µL was transferred to a vial for analysis.

Quantification by GC-FID: The quantification of the phytochemicals (plant chemical) present in the plants (*A. muricata* and *A. heterophyllus*) were done using BUCK M910 GC equipped with a flame ionization detector. The injector temperature was up to 280°C with split less injection of 2 µL of sample and a linear velocity of 30 cm^{-1}, the carrier gas used is Helium 5. 0 pa. s with a flow rate of 40 mL min^{-1}. The oven operated from a temperature of 200°C until it heated to 330°C at a rate of 3°C min^{-1}. This temperature was maintained for 5 min and the detector operated at a temperature of 320°C. The concentration of the different phytochemicals was expressed in µg g^{-1}.

RESULTS AND DISCUSSION

Quantitative phytochemical content of the leaves of *A. muricata*: The quantitative phytochemical content of the leaves of *A. muricata* is presented in Fig. 1.

Quantitative phytochemical content of the leaves of *A. heterophyllus*: The quantitative phytochemical screening of the leaves of *A. heterophyllus* is presented in Fig. 2.

The quantitative phytochemical screening of the plants using GC-FID showed that the leaves of *A. muricata* and *A. heterophyllus* are rich mainly in alkaloids and flavonoid (phenolic compounds).

Alkaloids are a group of naturally occurring plant secondary metabolites which contains basic nitrogen atoms in the heterocyclic ring and are derived from amino acids[22,23]. Alkaloids are known for their biological activities which include anti-oxidant activity, muscle relaxant property, anti-microbial, amoebicidal, anti-cancer and anti-diabetic activities[23].

Phenolic compounds are chemical substance that possess aromatic ring, they may contain one (phenol) or more (polyphenol) hydroxyl substituents[8]. Phenolic compounds are known for their anti-cancer, anti-bacterial and anti-fungal activities[8,24]. The presence of glycitein a phytoestrogen in the leaves of *A. heterophyllus*, in Table 1 shows that the plant may possess estrogenic activities[25].

The result of the present study shows that *A. muricata* and *A. heterophyllus* contains high concentration of catechin as shown in Table 1 and 2. Catechin is a natural occurring phenolic compound, it is known for its anti-oxidant activities. Besides having anti-oxidant activities, catechin have the potential to reduce cardiovascular disease, stroke, obesity

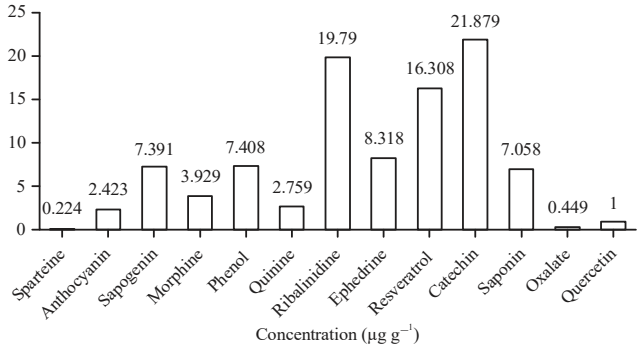

Fig. 1: Quantitative phytochemical content of *A. muricata* leaves

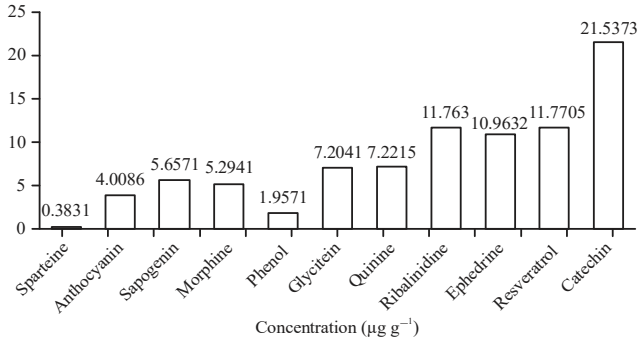

Fig. 2: Quantitative phytochemical content of the leaves of *A. heterophyllus*

Table 1: Phytochemical content of the leaves of *A. muricata*

Components	Class of phytochemical	Concentration (µg g^{-1})
Sparteine	Alkaloid	0.224
Anthocyanin	Flavonoid	2.423
Sapogenin	Steroids or triterpenes	7.391
Morphine	Alkaloid	3.929
Phenol	Flavonoid	7.408
Quinine	Alkaloid	2.759
Ribalinidine	Alkaloid	19.79
Ephedrine	Alkaloid	8.318
Resveratrol	Flavonoid	16.308
Catechin	Flavonoid	21.879
Saponin	Steroids or triterpenes	7.058
Oxalate		0.449
Quercetin	Flavonoid	1.000

Table 2: Phytochemical content of the leaves of *A. heterophyllus*

Components	Class of phytochemical	Concentration (µg g^{-1})
Sparteine	Alkaloid	0.3831
Anthocyanin	Flavonoid	4.0086
Sapogenin	Steroids or triterpenes	5.6571
Morphine	Alkaloid	5.2941
Phenol	Flavonoid	1.9571
Glycitein	Isoflavone (phytoestrogens)	7.2041
Quinine	Alkaloid	7.2215
Ribalinidine	Alkaloid compound	11.7630
Ephedrine	Alkaloid	10.9632
Resveratrol	Flavonoid	11.7705
Catechin	Flavonoid	21.5373

Table 3: Biological activities of the phytochemicals characterised in the leaves of *A. muricata* and *A. heterophyllus*

Components	Class of phytochemical	Uses
Sparteine	Alkaloid	Anti-arrhythmic, anti-convulsant, reduces locomotor activity[26]
Anthocyanin	Flavonoid	Anti-diabetic, delays cataracts in rats, improves vision[27]
Sapogenin	steroids or triterpenes	Anti-methanogenic potentials, modulate rumen fermentation[28]
Morphine	Alkaloid	Controls the brain, pain killer[29]
Phenol	Flavonoid	Acts as anti-oxidant[30]
Quinine	Alkaloid	Anti-malarial[31,32]
Ribalinidine	Quinoline Alkaloid	Free radical scavenging activity[33]
Ephedrine	Alkaloid	Temporary relief of shortness of breath, chest tightness and wheezing due to bronchial asthma, enhance mental function[34,35]
Resveratrol	Flavonoid	Cardioprotective, anti-arrhythmic agent, anti-obesity effect[36,37]
Catechin	Flavonoid	Antimicrobial, anti-cancer, prevents cardiovascular disease, improves blood pressure[38]
Saponin	Steroids or triterpenes	Antimicrobial, anti-fungal, anti-parasitic, insecticidal properties, lowering of serum cholesterol levels, cytotoxic agent[39]
Oxalate		No biological activity reported
Quercetin	Flavonoid	Anti-carcinogenic, anti-inflammatory and antiviral, reduces lipid peroxidation, protects the skin against UVB induced oxidative damage[40,41]
Glycitein	Isoflavone (phytoestrogens)	Atherosclerotic cardiovascular diseases, estrogenic activity, protects against beta amyloid-induced toxicity and oxidative stress[42]

and cancer[38]. This research also revealed the presence of morphine in both plants, morphine is in the class of drugs known as opioid. Morphine serve as analgesics and can easily be abused due to psychological dependence of it when taken for too long[29]. GC-FID analysis of the plants also revealed the presence of quinine, a type of alkaloid. A lot research has shown that quinine is an effective antimalarial drug[32].

Table 3 shows a brief summary of the biological activities of the phytochemicals present in the leaves of *A. muricata* and *A. heterophyllus*.

CONCLUSION

The role of phytochemicals cannot be over emphasised, various research on the activities of plants have shown that most plants possess one or more biological activities which has been attributed to their rich phytochemical contents. As shown in the Table 3, the leaves of *A. muricata* and *A. heterophyllus* possess mainly alkaloids and flavonoids (phenolic compounds) which have the potential to inhibit the activities of α-amylase and α-glucosidase enzyme. This could be exploited in the pharmacological production of antidiabetic drugs. The presence of glycitein an estrogenic compound in the leaves of *A. heterophyllus* may also serve as a potent drug to boost fertility while the presence of quinine in both plants shows that the plants can also be optimized in the pharmacological production of anti-malarial drugs.

SIGNIFICANCE STATEMENT

This study showed the quantitative phytochemical content of the leaves of *A. muricata* and *A. heterophyllus*. *A. muricata* and *A. heterophyllus* are used locally in the treatment of different diseases and infections. This research revealed that the leaves of these plants are rich in both alkaloids and flavonoids. The presence of quinine, morphine (alkaloids) and flavonoids (phenolic compounds) suggest that the plants may rightly be used locally as anti-malarial, pain relief and possibly anti-diabetic.

ACKNOWLEDGMENT

The Authors wish to thank Mr. David Okeke of spring board Laboratories for his efforts during this research.

REFERENCES

1. Tapera, M. and S. Machacha, 2017. Matrix solid phase dispersion extraction and screening of phytochemicals from *Dioscorea steriscus* tubers of Mashonaland Central province Zimbabwe. Der Chemica Sinica, 8: 117-122.
2. Patel, K., M. Gadewar, R. Tripathi, S.K. Prasad and D.K. Patel, 2012. A review on medicinal importance, pharmacological activity and bioanalytical aspects of beta-carboline alkaloid "Harmine". Asian Pac. J. Trop. Biomed., 2: 660-664.
3. Campos Vega, R. and B.D. Oomah, 2013. Chemistry and Classification of Phytochemicals. In: Handbook of Plant Food Phytochemicals: Sources, Stability and Extraction, Tiwari, B.K., N.P. Brunton and C.S. Brennan (Eds.)., John Wiley and Sons, Ltd., New York, pp: 5-48.
4. Khan, M.K., W. Karnpanit, S.M. Nasar Abbas, Z.E. Huma and V. Jayasena, 2015. Phytochemical composition and bioactivities of lupin: A review. Int. J. Food Sci. Technol., 50: 2004-2012.
5. Revathi, D. and M. Rajeswari, 2015. Phytochemical analysis of *Guettarda speciosa* Linn. Asian J. Plant Sci. Res., 5: 1-4.

6. Mith, H., R. Dure, V. Delcenserie, A. Zhiri, G. Daube and A. Clinquart, 2014. Antimicrobial activities of commercial essential oils and their components against food-borne pathogens and food spoilage bacteria. Food Sci. Nutr., 2: 403-416.
7. Tilaoui, M., H.A. Mouse, A. Jaafari and A. Zyad, 2015. Comparative phytochemical analysis of essential oils from different biological parts of *Artemisia herba alba* and their cytotoxic effect on cancer cells. Plos One, Vol. 10. 10.1371/journal.pone.0131799.
8. Oksana, S., B. Marian, R. Mahendra and S.H. Bo, 2012. Plant phenolic compounds for food, pharmaceutical and cosmeti c s production. J. Med. Plants Res., 6: 2526-2539.
9. Swamy, M.K., M.S. Akhtar and U.R. Sinniah, 2016. Antimicrobial properties of plant essential oils against human pathogens and their mode of action: An updated review. Evidence-Based Complement. Altern. Med., Vol. 2016. 10.1155/2016/3012462.
10. Adefegha, S.A., S.I. Oyeleye and G. Oboh, 2015. Distribution of phenolic contents, antidiabetic potentials, antihypertensive properties and antioxidative effects of soursop (*Annona muricata* L.) fruit parts *in vitro*. Biochem. Res. Int., Vol. 2015. 10.1155/2015/347673.
11. Florence, N.T., M.Z. Benoit, K. Jonas, T. Alexandra, D.D.P. Desire, K. Pierre and D. Theophile, 2014. Antidiabetic and antioxidant effects of *Annona muricata* (Annonaceae), aqueous extract on streptozotocin-induced diabetic rats. J. Ethnopharmacol., 151: 784-790.
12. Kossouoh, C., M. Moudachirou, V. Adjakidje, J.C. Chalchat and G. Figueredo, 2007. Essential oil chemical composition of *Annona muricata* L. leaves from Benin. J. Essent. Oil Res., 19: 307-309.
13. Hardoko, Y.H., S.V. Wijoyo and Y. Halim, 2015. *In vitro* antidiabetic activity of "green tea" soursop leaves brew through α-glucosidase inhibition. Int. J. PharmTech Res., 8: 30-37.
14. Moghadamtousi, S.Z., M. Fadaeinasab, S. Nikzad, G. Mohan, H.M. Ali and H.A. Kadir, 2015. *Annona muricata* (Annonaceae): A review of its traditional uses, isolated acetogenins and biological activities. Int. J. Mole Sci., 16: 15625-15658.
15. Onyechi, A. Uchenna, Ibeanu, V. Nkiruka and Eme *et al*., 2015. Nutrient, phytochemical composition and consumption pattern of soursop (*Annona muricata*) pulp and drink among workers in university of Nigeria, Nsukka. Pak. J. Nutr., 14: 866-870.
16. George, V.C., D.N. Kumar, P.K. Suresh and R.A. Kumar, 2015. Antioxidant, DNA protective efficacy and HPLC analysis of *Annona muricata* (soursop) extracts. J. Food Sci. Technol., 52: 2328-2335.
17. Madruga, M.S., F.S.M. de Albuquerque, I.R.A. Silva, D.S. do Amaral, M. Magnani and V.Q. Neto, 2014. Chemical, morphological and functional properties of *Brazilian jackfruit* (*Artocarpus heterophyllus* L.) seeds starch. Food Chem., 143: 440-445.
18. Prakash, O., R. Kumar, A. Mishra and R. Gupta, 2009. *Artocarpus heterophyllus* (Jackfruit): An overview. Pharmacogn. Rev., 3: 353-358.
19. Prakash, O., R. Kumar, D. Chandra, A. Kumar and P. Kumar, 2015. Effect of *Artocarpus heterophyllus* Lam. (Jackfruit) on indomethacin-induced ulcer model in albino rats. Der Pharm. Lett., 7: 81-85.
20. Swami, S.B., N.J. Thakor, P.M. Haldankar and S.B. Kalse, 2012. Jackfruit and its many functional components as related to human health: A review. Comprehen. Rev. Food Sci. Food Safety, 11: 565-576.
21. Prakash, O., J.A. Kumar and R. Gupta, 2013. Evaluation of anticonvulsant activity of *Artocarpus heterophyllus*Lam. leaves (Jackfruit) in mice. Der Pharm. Lett., 5: 217-220.
22. Babbar, N., 2015. An introduction to alkaloids and their applications in pharmaceutical chemistry. Pharma Innov. J., 4: 74-75.
23. Kaur, R. and S. Arora, 2015. Alkaloids-important therapeutic secondary metabolites of plant origin. J. Crit. Rev., 2: 1-8.
24. Huang, W.Y., Y.Z. Cai and Y. Zhang, 2009. Natural phenolic compounds from medicinal herbs and dietary plants: Potential use for cancer prevention. Nutr. Cancer, 62: 1-20.
25. Gutierrez-Zepeda, A., R. Santell, Z. Wu, M. Brown and Y. Wu *et al*., 2005. Soy isoflavone glycitein protects against beta amyloid-induced toxicity and oxidative stress in transgenic *Caenorhabditis elegans*. BMC Neurosci., Vol. 6. 10.1186/1471-2202-6-54.
26. Villalpando-Vargas, F. and L. Medina-Ceja, 2016. Sparteine as an anticonvulsant drug: Evidence and possible mechanism of action. Seizure, 39: 49-55.
27. Ghosh, D. and T. Konishi, 2007. Anthocyanins and anthocyanin-rich extracts: Role in diabetes and eye function. Asia Pac. J. Clin. Nutr., 16: 200-208.
28. Sirohi, S.K., N. Goel and N. Singh, 2014. Influence of *Albizia lebbeck* saponin and its fractions on *in vitro* gas production kinetics, rumen methanogenesis and rumen fermentation characteristics. ISRN Vet. Sci., Vol. 2014. 10.1155/2014/498218.
29. Beltran-Campos, V., M. Silva-Vera, M.L. Garcia-Campos and S. Diaz-Cintra, 2015. Effects of morphine on brain plasticity. Neurologia, 30: 176-180.
30. Orcic, D.Z., N.M. Mimica-Dukic, M.M. Franciskovic, S.S. Petrovic and E.D. Jovin, 2011. Antioxidant activity relationship of phenolic compounds in *Hypericum perforatum* L. Chem. Central J., Vol. 5. 10.1186/1752-153X-5-34.

31. Achan, J., A.O. Talisuna, A. Erhart, A. Yeka and J.K. Tibenderana *et al*., 2011. Quinine, an old anti-malarial drug in a modern world: Role in the treatment of malaria. Malaria J. Vol. 10. 10.1186/1475-2875-10-144
32. Gachelin, G., P. Garner, E. Ferroni, U. Trohler and I. Chalmers, 2017. Evaluating Cinchona bark and quinine for treating and preventing malaria. J. R. Soc. Med., 110: 73-82.
33. Nwiloh, B.I., A.A. Uwakwe and J.O. Akaninwor, 2016. Phytochemical screening and GC-FID analysis of ethanolic extract of root bark of *Salacia nitida* L. Benth. J. Med. Plant Stud., 4: 283-287.
34. Poornahavandi, H.R. and M.J. Zamiri, 2008. Effects of ephedrine and its combination with caffeine on body composition and blood attributes of fat-tailed Mehraban lambs. Iran. J. Vet. Res., 9: 51-58.
35. Lieberman, H.R., 2001. The effects of ginseng, ephedrine and caffeine on cognitive performance, mood and energy. Nutr. Rev., 59: 91-102.
36. Hung, L.M., J.K. Chen, S.S. Huang, R.S. Lee and M.J. Su, 2000. Cardioprotective effect of resveratrol, a natural antioxidant derived from grapes. Cardiovasc. Res., 47: 549-555.
37. Bird, J.K., D. Raederstorff, P. Weber and R.E. Steinert, 2017. Cardiovascular and antiobesity effects of resveratrol mediated through the gut microbiota. Adv. Nutr., 8: 839-849.
38. Kajiya, K., H. Hojo, M. Suzuki, F. Nanjo, S. Kumazawa and T. Nakayama, 2004. Relationship between antibacterial activity of (+)-catechin derivatives and their interaction with a model membrane. J. Agric. Food Chem., 52: 1514-1519.
39. Moses, T., K.K. Papadopoulou and A. Osbourn, 2014. Metabolic and functional diversity of saponins, biosynthetic intermediates and semi-synthetic derivatives. Crit. Rev. Biochem. Mol. Biol., 49: 439-462.
40. Li, Y., J. Yao, C. Han, J. Yang and M.T. Chaudhry *et al*., 2016. Quercetin, inflammation and immunity. Nutrients, Vol. 8. 10.3390/nu8030167.
41. Yin, Y., W. Li, Y.O. Son, L. Sun and J. Lu *et al*., 2013. Quercitrin protects skin from UVB-induced oxidative damage. Toxicol. Applied Pharmacol., 269: 89-99.
42. Pan, W., K. Ikeda, M. Takebe and Y. Yamori, 2001. Genistein, daidzein and glycitein inhibit growth and DNA synthesis of aortic smooth muscle cells from stroke-prone spontaneously hypertensive rats. J. Nutr., 131: 1154-1158.