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ANTIOXIDANT POTENTIAL AND HEALTH BENEFITS OF PURPLE SWEET POTATO LEAVES (*IPOMOEA BATATAS* L.)

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ABSTRAK

Radikal bebas merupakan molekul yang memiliki satu atau lebih elektron yang tidak berpasangan sehingga sangat labil dan reaktif. Radikal bebas berperan penting dalam kerusakan jaringan dan proses patologis pada organisme hidup. Sumber radikal bebas endogen berupa sisa metabolisme, seperti proses pembakaran dalam tubuh, protein, karbohidrat, dan lemak yang kita konsumsi, serta sumber radikal bebas eksogen yang berasal dari polusi udara, asap kendaraan bermotor, serta berbagai zat kimia dan sinar ultraviolet. 1, 2 Peningkatan radikal bebas dapat menimbulkan stres oksidatif sehingga terjadi kerusakan oksidatif mulai dari tingkat jaringan seluler hingga organ yang akan mempercepat proses penuaan dan menimbulkan berbagai patogenesis penyakit. 3 Untuk mengurangi dampak stres oksidatif, diperlukan antioksidan yang cukup, yang dapat diperoleh dari dalam tubuh melalui enzim maupun asupan antioksidan alami. 4 Salah satu sumber antioksidan alami berasal dari daun tanaman ubi jalar ungu (Ipomea batatas L) yang mengandung senyawa kimia seperti betakaroten, bioflavonoid, katekin, dan polifenol yang dapat menangkal radikal bebas, memperbaiki kondisi stres oksidatif sehingga bermanfaat untuk menjaga kesehatan.

ABSTRACT

Antioxidant Potential and Health Benefits of Purple Sweet Potato Leaves (Ipomoea batatas L.) Free radicals are molecules with one or more unpaired electrons, which makes them very labile and reactive. They are important in tissue damage and pathological processes in living organisms. Endogenous sources of free radicals are metabolic waste, such as combustion processes in the body, proteins, carbohydrates, and fats that we consume, and exogenous ones that come from air pollution, vehicle exhaust, and various chemicals and ultraviolet rays. 1, 2 An increase in free radicals can cause oxidative stress, resulting in oxidative damage from the cellular tissue to organ levels that will accelerate aging and cause various disease pathogenesis. 3 To reduce the impact of oxidative stress, adequate antioxidants are needed, which can be obtained from the body through enzymes or natural antioxidant intake. 4 One source of natural antioxidants comes from the leaves of purple sweet potato plants (Ipomea batatas L), which contain chemical compounds such as beta-carotene, bioflavonoids, catechins, and polyphenols that can ward off free radicals, improve oxidative stress conditions so that they are beneficial for maintaining health.

INTRODUCTION

Free radicals are products that arise from using oxygen to produce energy, namely as a result of the production of *adenosine triphosphate* (ATP) by mitochondria. These byproducts can be *reactive oxygen species* (ROS) and *reactive nitrogen species* (RNS). Increased levels of ROS and RNS indicate oxidative stress. [7] Oxidative stress is a damaging process that can seriously alter cell membranes and other structures such as proteins, lipids, lipoproteins, and *deoxyribonucleic acid* (DNA). This can be explained by the excessive production of hydroxyl radicals and peroxynitrite, which can damage cell membranes and lipoproteins through lipid peroxidation. Lipid peroxidation occurs through a radical chain reaction that spreads rapidly and affects many lipid molecules. In addition, the ROS/RNS reaction can damage proteins, causing structural changes and loss of enzyme activity. [1,2,5,6] Oxidative damage to DNA causes various oxidative DNA lesions that can cause mutations. If not properly regulated, oxidative stress can cause various chronic and degenerative diseases as well as the aging process and some acute pathologies (trauma, stroke). [1,5,6]

The body has several mechanisms to combat these attacks using DNA repair enzymes and/or antioxidants. To overcome oxidative stress conditions, synthetic antioxidants must be provided from external sources to strengthen the internal antioxidant defense mechanisms. Due to their therapeutic potential, several medicinal plants have been reported as major sources of natural antioxidant phytochemicals. [8] One of these plants is the purple sweet potato, or *Ipomea batatas* L. in addition to its tubers, which are the main source of starch, purple sweet potato leaves are known to be rich in antioxidants. Sweet potato leaves contain various flavonoid compounds, such as salidroside, kaempferol, rhamnocitrin, astragalin, rhamnetin , quercetin, tannins, and saponins. [5-7] Research conducted by Luo revealed that the total polyphenol content, such as anthocyanins and phenolic acids, in 40 sweet potato leaf cultivars ranged from 3-12% of dry weight. This amount is two to three times higher than the total polyphenols in spinach and kale (*Brassica oleracea*). Polyphenols found in sweet potato leaves have high antioxidant capacity and the ability to neutralize free radicals, chelate metals, and inhibit lipid peroxidation. [9-11]

METHOD

The preparation of this review article uses a literature study method from several primary sources, such as national and international scientific articles and online media, namely Google and journal sites (PubMed, NCBI, Mendeley, ACS, etc.), which aim to increase knowledge and understanding of the topic being discussed, as well as provide facts (new analysis) that can be used as a comparison of the results presented in the review article.

RESULTS

Indonesia is a *megadiversity country* with plant diversity. Indonesia has around 30,000 to 35,000 types of plants. Some flora are classified as superfoods, including purple sweet potatoes. [12] Sweet potato tubers in Indonesia are mostly used as food and have the potential to replace rice as the main food because they are more efficient in producing energy, vitamins, and minerals. [3] However, several recent studies have stated that plants, especially purple ones, in this case purple sweet potatoes, both tubers and leaves, are one source of antioxidants namely they can capture free radicals and have many health benefits, including playing a role in preventing aging, cancer, and degenerative diseases. [2,3,4]

Stress Oxidative

Oxidative stress is a state of imbalance between oxidants and which ultimately causes damage to the body's biological systems. [5] Oxidative stress can be a mechanism for the onset of disease in two ways, namely by increasing the production of reactive species, either oxygen or nitrogen, which will directly oxidize macromolecules, including membrane lipids, structural proteins, enzymes, and nucleic acids, causing abnormal cell function to cell death. The second way is by increasing the production of lipid peroxidation, including 4-hydroxy-2-nonenal (HNE), which can also cause abnormal signals in body cells. Therefore, Oxidative stress has been associated with a variety of pathologies and is grouped into two categories below: first, oxidative stress as the primary cause of pathology (including toxicity caused by radiation and atherosclerosis); second, oxidative stress as a secondary contributor to the development of diseases such as COPD, hypertension and Alzheimer's disease. [6,7]

Antioxidants

Antioxidants are substances that function to protect cells from damage caused by unstable molecules known as free radicals. Antioxidants can slow down or prevent the oxidation of other molecules. Antioxidants can be classified into endogenous and exogenous antioxidants. Endogenous antioxidants can be enzymes, such as superoxide dismutase, catalase, glutathione peroxidase, glutathione reductase, and minerals such as selenium, cuprum, iron, and zinc. The body cannot produce exogenous antioxidants, which must be obtained from food, including vitamin E, vitamin C, trace elements (Se, Cu, Zn, Mn), and phytochemicals such as isoflavones, polyphenols, and flavonoids. The active interaction of endogenous and exogenous antioxidants has also been proven that using exogenous antioxidants can increase the activity of endogenous antioxidants, such as vitamin E, given orally to humans, which induces a significant increase in red blood cell glutathione levels. [1,13]

Purple Sweet Potato Leaves

Ipomoea batatas (L.) Lam or sweet potato is a dicotyledonous plant originating from the tropics, with China and Spain as the main producers from outside and inside the European Union. The differences in sweet potato color can be grouped into categories based on skin color and flesh color. Sweet potato skin colors include white, cream, yellow, orange, pink, red, and purple. The flesh colors include white, cream, yellow, orange, and purple. The roots, including the flesh only, are edible;. However, the leaves are also edible and consumed as leafy or green vegetables in some parts of Asia; these leaves are often discarded. The content of minerals, vitamins, proteins, pigments, and antioxidants such as polyphenols are also found in the leaves. [14-17]

The antioxidant content in purple sweet potatoes, both in tubers and leaves, is relatively high. More than 100 bioactive compounds, such as flavonoids, non-flavonoids, carotenoids, or organic acids, have been identified. [18,19] Anthocyanins, responsible for the color of purple-fleshed sweet potatoes, are one of the important antioxidants causing the general purple color of the skin and flesh and some leaves. Other compounds are phenolic compounds, such as ferulic acid and caffeic acid, which play a role in increasing the stability of anthocyanins. The chlorogenic acid and caffeic acid groups and their derivatives are the most widely distributed phenolic acids in the leaves and skin of purple sweet potatoes. [19]

Non-anthocyanin flavonoids, including flavonols, flavans, and flavones, have also been identified. [20] A good source of flavonols and flavones is found in the tuber flesh, where kaempferol, luteolin, and myricetin are the major constituents, while quercetin is mainly found in the leaves and peel. These compounds play significant biological regulatory functions, such as their remarkable effects on protein regulation by reversibly combining with various proteins and enzymes in the body. [21] Purple sweet potato has high vitamin C and E content in the flesh; some studies have found low amounts in the peel and leaves. Vitamin C is involved in collagen biosynthesis, cholesterol metabolism, iron pathway modulation, and reactive oxygen and nitrogen species scavenging as part of its antioxidant mechanism. [22]

In addition to performing essential functions in plants, these compounds, once ingested, can perform protective functions against ROS formation and oxidative damage and play an important role in stabilizing anthocyanin color. [23,24] Although ROS act as signaling molecules in physiological functions, excessive ROS production can damage lipids, membranes, proteins, or DNA, resulting in oxidative stress and damage. [25,26] In addition, Insanu et al. found that higher phenolic acid and flavonoid content had higher antioxidant activity, indicating that the highest activity was found in leaves. [27]

Research by Chang et al., by giving a purple sweet potato leaf diet to a group of athletes induced by exercise stress, found that consuming foods high in polyphenols can modulate antioxidant status and reduce exercise-induced oxidative damage and pro-inflammatory cytokine secretion. [28] Oxidative stress is an imbalance between ROS production and its elimination through a protective mechanism. [29] This protection can be explained by the anthocyanin and polyphenol content in purple sweet potato leaves. Anthocyanins induce antioxidant expression through the erythroid 2-related factor 2 (Nrf2) pathway and by reducing inflammation. [30] Meanwhile, polyphenols reduce the catalytic activity of enzymes involved in ROS formation, such as *nitric oxide* (NO) synthesis or *xanthine oxidase* (XO). [31,32] Several studies have reported that antioxidant activity is positively correlated with *the total phenolic capacity* (TPC) of purple sweet potato leaves. [33,34]

Several studies have shown beneficial effects due to the hypoglycemic action of purple sweet potato leaves. Solihah et al. evaluated the effects of purple sweet potato leaves on alloxan-induced diabetic rats and found decreased blood glucose levels. As well as better histopathological images of the pancreas than untreated animals. [35] The mechanism that could explain this is likely because polyphenols, anthocyanins, and protein-bound anthocyanins can increase *AMP-activated protein kinase* (AMPK), which causes increased levels of glucose transporter type 2 (GLUT2), glucokinase protein (GK), and *insulin receptor α* (INSR). [36] Various bioactive compounds with different target actions determine purple sweet potato leaves' hypoglycemic and antidiabetic effects.

Purple sweet potato leaves are also known to have neuroprotective effects. Research by Kang et al. observed the neuroprotective effects of purple sweet potato leaves on lipopolysaccharide-induced BV-2 microglia cells, obtained scavenging of 2,2 diphenyl-1-picrylhydrazide (DPPH) radicals, and reduced NO release and concentrations of inflammatory mediators such as *inducible nitric oxide synthetase* (iNOS), COX-2, and *Tumor necrosis factor alpha* (TNF-α). Meanwhile, the mechanism of anthocyanins in neurodegenerative diseases is thought to be due to four effects: (i) the ability to scavenge radicals to eliminate ROS and RNS and promote antioxidant enzymes, (ii) inhibition of inflammatory pathways in the central nervous system (CNS),

(iii) cytoprotective and anti-apoptotic effects on neurons; and (iv) promotion of cholinergic neurotransmission. [37]

CONCLUSION

Ipomea batatas L, or purple sweet potato, is widely grown worldwide because of its unique color, nutrition, and health benefits. Purple sweet potatoes contain a lot of high antioxidant activity in their flesh/tubers. Recent data states that the antioxidant content is not limited to the tubers of purple sweet potatoes but also in their leaves. Purple sweet potato leaves contain anthocyanins, kaempferol, quercetin, ferulic acid, caffeic acid, and many others. These antioxidants can reduce oxidative stress that can trigger disease pathogenesis, so they are useful for maintaining body health.

Several in vivo studies have shown the benefits of purple sweet potato leaves, including providing a purple sweet potato leaf diet in a group of athletes, resulting in decreased oxidative stress. In a study with alloxan induction, purple sweet potato leaves showed antihyperglycemic effects and improved pancreatic gland histopathology, and in an in vitro study, it was found that purple sweet potato leaves had a neuroprotective effect of purple sweet potato leaves on lipopolysaccharide-induced BV-2 microglia cells.

Although the benefits of purple sweet potatoes have been widely recognized, studies related to purple sweet potato leaves are still minimal. To avoid becoming a mere waste byproduct, further research is needed to explore the mechanism and use of purple sweet potato leaves for wider benefits.

REFERENCES

1. Byproducts from Cultivation and Processing of Sweet Potatoes. Ciência Rural[Internet]. 2017;47:e20160610. Available from; https://doi.org 10.1590/0103-8478cr20160610.
2. Chang W.-H., Hu S.-P., Huang Y.-F., Yeh T.-S., Liu J.-F. Effect of Purple Sweet Potato Leaves Consumption on Exercise-Induced Oxidative Stress and IL-6 and HSP72 Levels. J. Appl. Physiol[Internet]. 2010;109:1710–1715. Available from;10.1152/japplphysiol.00205.2010.
3. Chaudhary Priya et al. Oxidative stress, free radicals and antioxidants: potential crosstalk in the pathophysiology of human diseases. Frontiers in Chemistry [Internet. Vol11.2023.https://www.frontiersin.org/journals/chemistry/articles/10.3389/fchem.2023.1158198. Available from; https://doi.org 10.3389/fchem.2023.1158198. ISSN.2296-2646
4. Cui L., Liu C.-Q., Li D.-J., Song J.-F. Effect of Processing on Taste Quality and Health-Relevant Functionality of Sweet Potato Tips. Agric. Sci. China[Internet] . 2011;10:456–462. Available from; https://doi.org 10.1016/S1671-2927(11)60025-4.
5. Forman, H.J., Zhang, H. Targeting oxidative stress in disease: promise and limitations of antioxidant therapy. *Nat Rev Drug Discov* [Internet] .20, 689–709 (2021). Available from; https://doi.org/10.1038/s41573-021-00233-1
6. Gan L.J., Yang D., Shin J.A., Kim S.J., Hong S.T., Lee J.H., Sung C.K., Lee K.T. Oxidative Comparison of Emulsion Systems from Fish Oil-Based Structured Lipid versus Physically Blended Lipid with Purple-Fleshed Sweet Potato (Ipomoea batatas L.) Extracts. J. Agric. Food Chem[Internet]. 2012;60:467–475.Available from; https://doi.org 10.1021/jf203708y.
7. Grace M.H., Yousef G.G., Gustafson S.J., Truong V.D., Yencho G.C., Lila M.A. Phytochemical Changes in Phenolics, Anthocyanins, Ascorbic Acid, and Carotenoids Associated with

Sweetpotato Storage and Impacts on Bioactive Properties. Food Chem[Internet]. 2014;145:717–724. Available from; https://doi.org 10.1016/j.foodchem.2013.08.107

8. Guclu G., Dagli M.M., Aksay O., Keskin M., Kelebek H., Selli S. Comparative Elucidation on the Phenolic Fingerprint, Sugars and Antioxidant Activity of White, Orange and Purple-Fleshed Sweet Potatoes (Ipomoea batatas L.) as Affected by Different Cooking Methods. Heliyon[Internet]. 2023;9:e18684. Available from; https://doi.org 10.1016/j.heliyon.2023.e18684.
9. Hamda, Ahmad M.Q., Saleem A., Yan H., Li Q. Biofortified Sweet Potato—An Ideal Source of Mitigating Hidden Hunger. Biofortification Grain Veg. Crops Mol. Breed. Approaches[Internet]. 2024;12:239–253. Available from; https://doi.org 10.1016/B978-0-323-91735-3.00013-3.
10. Handa O. Implementation of the Earth Space Theme in the Design of Botanical Recreation and Education Facilities in Central Jakarta. Reka Karsa J Arsit.2014;2(3)
11. Hussain T., Tan B., Yin Y., Blachier F., Tossou M.C.B., Rahu N. Oxidative Stress and Inflammation: What Polyphenols Can Do for Us? Oxidative Med. Cell. Longev[Internet]. 2016;2016:7432797.Available from; https://doi.org 10.1155/2016/7432797.
12. Hwang Y.P., Choi J.H., Yun H.J., Han E.H., Kim H.G., Kim J.Y., Park B.H., Khanal T., Choi J.M., Chung Y.C., et al. Anthocyanins from Purple Sweet Potato Attenuate Dimethylnitrosamine-Induced Liver Injury in Rats by Inducing Nrf2-Mediated Antioxidant Enzymes and Reducing COX-2 and INOS Expression. Food Chem. Toxicol[Internet]. 2011;49:93–99. Available from; https://doi.org 10.1016/j.fct.2010.10.002.
13. Insanu M., Amalia R., Fidrianny I. Potential Antioxidative Activity of Waste Product of Purple Sweet Potato (Ipomoea batatas Lam) Pak. J. Biol. Sci[Internet]. 2022;25:681–687. Available from; https://doi.org 10.3923/pjbs.2022.681.687.
14. Insanu, Muhamad et al. "Potential Antioxidative Activity of Waste Product of Purple Sweet Potato (*Ipomoea batatas* Lam.)." *Pakistan journal of biological sciences : PJBS* [Internet] . 2022; vol. 25.8 : 681-687. Available from; https://doi.org 10.3923/pjbs.2022.681.687
15. Jiang T., Shuai X., Li J., Yang N., Deng L., Li S., He Y., Guo H., Li Y., He J. Protein-Bound Anthocyanin Compounds of Purple Sweet Potato Ameliorate Hyperglycemia by Regulating Hepatic Glucose Metabolism in High-Fat Diet/Streptozotocin-Induced Diabetic Mice. J. Agric. Food Chem[Internet]. 2020;68:1596–1608 . Available from; https://doi.org 10.1021/acs.jafc.9b06916.
16. Jin Q., Liu T., Qiao Y., Liu D., Yang L., Mao H., Ma F., Wang Y., Peng L., Zhan Y. Oxidative Stress and Inflammation in Diabetic Nephropathy: Role of Polyphenols. Front. Immunol[Internet]. 2023;14:1185317.Available from; https://doi.org 10.3389/fimmu.2023.1185317.
17. Kang H., Kwak Y.G., Koppula S. Protective Effect of Purple Sweet Potato (Ipomoea batatas Linn, Convolvulaceae) on Neuroinflammatory Responses in Lipopolysaccharide-Stimulated Microglial Cells. Trop. J. Pharm. Res[Internet]. 2014;13:1257–1263. Available from; https://doi.org 10.4314/tjpr.v13i8.9.
18. Liao, Wayne C et al. "Antioxidative activity of water extract of sweet potato leaves in Taiwan." *Food chemistry* [Internet]. 2011;vol. 127,3: 1224-8. Available from; https://doi.org 10.1016/j.foodchem.2011.01.131
19. Lv X., Mu J., Wang W., Liu Y., Lu X., Sun J., Wang J., Ma Q. Effects and Mechanism of Natural Phenolic Acids/Fatty Acids on Copigmentation of Purple Sweet Potato Anthocyanins. Curr. Res. Food Sci[Internet]. 2022;5:1243–1250. Available from; https://doi.org 10.1016/j.crfs.2022.08.003.

20. Martemucci G, Costagliola C, Mariano M, D'andrea L, Napolitano P, D'Alessandro AG. Free Radical Properties, Source and Targets, Antioxidant Consumption and Health. *Oxygen* [Internet]. 2022; 2(2):48-78. Available from; https://doi.org/10.3390/oxygen2020006
21. Nur khasanah, Muhammad Saiful Bahri, Sapto Yulianto. Antioxidants and Oxidative Stress. Yogyakarta; UAD Press. 2023
22. Philpott M., Gould K.S., Lim C., Ferguson L.R. In Situ and In Vitro Antioxidant Activity of Sweetpotato Anthocyanins. J. Agric. Food Chem[Internet]. 2004;52:1511–1513. Available from; https://doi.org 10.1021/jf034593j.
23. Pramesti R, Widyastuti M. The effect of giving sweet potato leaf juice (Ipomeabatatas (L Lam) on LDL cholesterol levels in male Wistar rats (Rattus novergicus) fed high fat; 2014
24. Putri WNE, Astuti NMW. Potential of Sweet Potato Leaf Extract (Ipomea batatas L) as a blood sugar lowering supplement 2022; P.244-59
25. Richardson M.L., Arlotta C.G. Growing Sweet Potatoes [Ipomoea batatas (L.) Lam.)] for Their Greens and the Impact on Storage Roots. J. Hortic. Sci. [Internet] 2023;18:2. Available from; https://doi.org 10.24154/jhs.v18i2.1932.
26. Schieber M., Chandel N.S. ROS Function in Redox Signaling and Oxidative Stress. Curr. Biol[Internet]. 2014;24:PR453–PR462. Available from; https://doi.org 10.1016/j.cub.2014.03.034.
27. Setiawati A, FitriantiVY, Masruhim MA. Anti-inflammatory activity of sweet potato leaf extract (Ipomea batatas Poir) on white rats (Rattus Novergicus). J.Science and Health 2016;1 (6): 316-20
28. Sharifi-Rad Mehdi et al.Lifestyle, Oxidative Stress, and Antioxidants: Back and Forth in the Pathophysiology of Chronic Diseases. Frontiers in Physiology [Internet]. Volume 11, 2020. Available from; https://www.frontiersin.org/journals/physiology/articles/10.3389/fphys.2020.00694. DOI 10.3389/fphys.2020.00694. ISSN=1664-042X
29. Sir Elkhatim K.A., Elagib R.A.A., Hassan A.B. Content of Phenolic Compounds and Vitamin C and Antioxidant Activity in Wasted Parts of Sudanese Citrus Fruits. Food Sci. Nutr[Internet]. 2018;6:1214–1219. Available from; https://doi.org 10.1002/fsn3.660.
30. Solihah I., Herlina H., Munirah E., Haryanti H., Amalia M., Rasyid R.S.P., Suciati T., Fatma F. The Hypoglycemic Effect of Purple Sweet Potato Leaf Fractions in Diabetic Rats. J. Adv. Pharm[Internet]. Educ. Res. 2023;13:64–72.Available from; https://doi.org 10.51847/rQSvc5gZwg.
31. Sun, Hongnan et al. "Sweet potato (Ipomoea batatas L.) leaves as nutritional and functional foods." *Food chemistry* [Internet] .2014; vol. 156: 380-9. Available from; https://doi.org 10.1016/j.foodchem.2014.01.079
32. Terahara N. Flavonoids in Foods: A Review. Nat. Prod. Commun[Internet]. 2015;10:1934578X1501000334. Available from; https://doi.org 10.1177/1934578X1501000334.
33. Tu W., Wang H., Li S., Liu Q., Sha H. The Anti-Inflammatory and Antioxidant Mechanisms of the Keap1/Nrf2/ARE Signaling Pathway in Chronic Diseases. Aging Dis[Internet]. 2019;10:637–651. Available from; https://doi.org 10.14336/AD.2018.0513.
34. Valko M., Leibfritz D., Moncol J., Cronin M.T.D., Mazur M., Telser J. Free Radicals and Antioxidants in Normal Physiological Functions and Human Disease. Int. J. Biochem. Cell Biol[Internet]. 2007;39:44–84. Available from; https://doi.org 10.1016/j.biocel.2006.07.001.

35. Wang A., Li R., Ren L., Gao X., Zhang Y., Ma Z., Ma D., Luo Y. A Comparative Metabolomics Study of Flavonoids in Sweet Potato with Different Flesh Colors (Ipomoea batatas (L.) Lam) Food Chem. 2018;260:124–134. Available from; https://doi.org 10.1016/j.foodchem[Internet].2018.03.125.
36. Willcox JK, Ash SL, Catignani GL. Antioxidants and prevention of chronic disease. *Crit Rev Food Sci Nutr* [Internet] . 2004;44(4):275-295. Available from; https://doi.org 10.1080/10408690490468489
37. Xu W., Liu L., Hu B., Sun Y., Ye H., Ma D., Zeng X. TPC in the Leaves of 116 Sweet Potato (Ipomoea batatas L.) Varieties and Pushu 53 Leaf Extracts. J. Food Compos. Anal[Internet]. 2010;23:599–604.Available from; https://doi.org 10.1016/j.jfca.2009.12.008