ORIENTAL JOURNAL OF CHEMISTRY
An International Open Access, Peer Reviewed Research Journal
www.orientjchem.org
Est. 1984
ISSN: 0970-020 X
CODEN: OJCHEG
2022, Vol. 38, No.(3):
Pg. 663-670

An Approach to Leading Antioxidant Activity of Different Plants and Food Material: (A Mini Review)

KUSUM SONI[1]* and SANGEETA LOONKER[2]

[1*,2]Department of Chemistry, Jai Narain Vyas University, Jodhpur, Rajasthan, India.
*Corresponding author E-mail: Kusumsonid1993@gmail.com

http://dx.doi.org/10.13005/ojc/380316

(Received: May 01, 2022; Accepted: June 17, 2022)

ABSTRACT

Antioxidants are molecules that battle against free radicals in the body. Free radicals are compounds that can damage the body if it gets too strong. They are associated with many illnesses such as diabetes, cardiovascular disease, and cancer etc. The body has its defense system against antioxidants to regulate free radicals. Antioxidants are also found in foods, particularly fruits, vegetables, and other substances based on herbs. Vitamins E and C are very important antioxidants. Plants have recently become a significant source of a surprising number of antioxidants that avoid the oxidative stress of free radicals. Natural chemicals, particularly those from medicinal plants, give many beneficial antioxidants. Antioxidant preservatives also play the main role in rising shelf life in food processing. Alcohol, green tea, cocoa, and dark chocolate are popular as strong antioxidant sources. Antioxidants can increase the self-life of both natural and processed foods. As a result, they're commonly employed as food additives. In these cases, the activity has been increased by the increasing use of three different methods. This review aims to determine the antioxidant activity of historically beneficial and modern medicinal plants.

Keywords: Medicinal plant, Antioxidant activity, Food, Free radical.

INTRODUCTION

Free radicals assume a fundamental work in different neurotic conditions, for example, tissue injury, irritation process, and neurodegenerative maladies. Cell reinforcements have a significant job to ensure the human body against harm by the free radicals[1]. All things considered, there is constrained information about pharma's sensible and natural exercises of the sweet-smelling plants. A plant named *Centaurea* is one the of most significant genera of the family Asteraceae. The genus *Centaurea* consists of 400 and 700 diffident kinds of species[2-4] andvarious of them rising in different parts of the world[5-6]. Many *Centaurea* species have therapeutic uses, including *C. depressa*, *C. solsititialis*[7], *C. pulchella*[8] and *C. drabifolia*[9]. Some *Centaurea* species such as *C. spatula*, *C. pulchella*, *C. Huber-morathi* and *C. mucronifera* were studied[10-13] in terms of biological assets. However, there are only a few kinds of literature related to the fatty acid profile of *Centaurea* species[14]. *C. urvilleisubsp. Hayekian* grows naturally in Turkey.

This has pulled in a lot of research enthusiasm for common antioxidant agents. In this manner, an overall pattern towards the utilization of regular phytochemicals present in berry crops, tea, herbs, oilseeds, beans, natural products, and vegetables has expanded. A few herbs and flavors have been accounted for to show antioxidant agent movement, including rosemary, sage, thyme, nutmeg, turmeric, white pepper, bean stew pepper, ginger, and a few Chinese restorative plants extract. The above mixtures, as well as vitamins C and E, β-carotene, and tocopherol, are known to have antioxidant properties. The deliberate record of the relative antioxidant agent movement in chosen Iranian restorative plant species extracts was recorded by Pourmand *et al.,* in 2006. According to the study done on the medicinal plant, a plant named Lippia-alba has a lot of medicinal properties and also has a unique active ingredient in it, it belongs to the *Verbenaceae* family[15-20]. *Cassia angustifolia Vahl*. (Caesalpiniaceae) commonly in India known as *Sannamakkai*, it is being used as a medicine since ancient times, even today it is a popular medicine that is being widely used. It generally develops in the dry and hot regions of Pakistan and India[21]. Furthermost pharmacopeias the world has also verified this plant as a medicinal plant[22]. Due to its cathartic properties, it is very useful as it proves very useful in removing habitual constipation[23]. And also act as amoebic dysentery and liver activator. It is widely used as a febrifuge in splenic increases, cholera, anemia, typhoid[24], laxative, genotoxicity, and toxicity in *Escherichia coli*[25]. Leaves of *C. angustifoliaia* are also used as a safe laxative and this plant contributes considerably to commercial drugs and has been investigated in several parts of the world for various therapeutic preparations in different ways[26].

Some scientists isolated low-polarity components from mulberry roots with hexane and butanol, then tested the extracted solution for beneficial compounds such prenyflavas, glycoside, isoquercetin, and astragalin[27]. Pistacia species have been used to cure a number of diseases in traditional medicine[28]. Recent research has discovered that the oil obtained from several parts of this plant, including leaves, fruits, gum, and nuts, has antibacterial, insecticide, anti-inflammatory, and antiseptic properties, among others. The various terpenes obtained in it have many medicinal properties and some antioxidant properties[29-34]. Only a few data have been reported about the antioxidant content of preparations from the Pistacia species.

In aqueous extracts from shrubberies and the gum of *P. lentiscus*[35-36], galloyl quininic compounds were detected, while R-tocopherol was measured in lipophilic extracts from the leaves of *P. lentiscus* and *P. therebintus*[37].

Antioxidants types and working

Classification of Antioxidants

Natural and synthetic antioxidants are the two main forms of antioxidants, based on their source (Schematic representation of a classification of antioxidants in Fig. 2.1). Natural antioxidants are produced in the human body or taken from other natural sources, and their activity is largely dictated by their physical and chemical characteristics, as well as their mode of action. Enzymatic antioxidants and nonenzymatic antioxidants are two different types of antioxidants. In Fig. 2.1 taxonomy of antioxidants is shown schematically. Various metabolic activities in the human body produce enzyme antioxidants. Antioxidants are divided into two categories: primary and secondary antioxidants. The most frequent main antioxidants are superoxide dismutase (SOD), catalase (CAT), and glutathione peroxidase (GPx)[38]. Glutathione reductase (GR) and glucose-6-phosphate dehydrogenase (G6PD) are secondary antioxidants (G6PDH). NADPH is produced by G6PDH.[39] Nonenzymatic antioxidants are not found in the human body and must be taken as supplements for the human body's regular metabolism to remain stable[40].

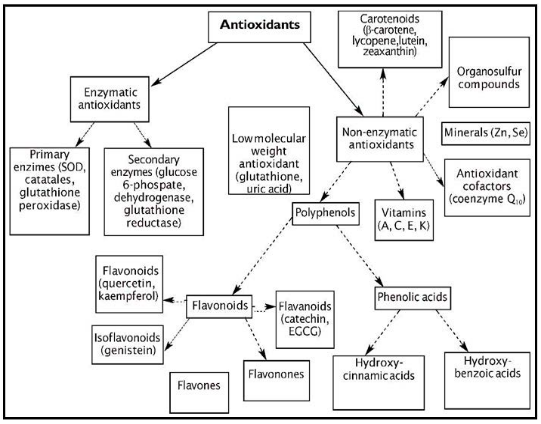

Fig. 2.1 Schematic representation of the classification of antioxidants

Minerals, vitamins, carotenoids, polyphenols, and other antioxidants are examples of nonenzymatic antioxidants, as shown in the chart. Minerals are essential for the enzymes to operate properly in the bodily cells. Minerals are necessary for the efficient functioning of mineral enzymes, which are responsible for the health care of bodily cells. Their deficiency or absence leads to further abnormalities in the quality and function of various macromolecules present in the body and cells. Vitamins from the class of micronutrients are responsible for the normal metabolic processes of the body and at the same time it is also a major factor for antioxidant activity, such as vitamin A, vitamin B, vitamin E, and vitamin C. Vitamins are not synthesized in the body, they are ingested by accompanied in the diet. Carotenoid content of β-carotene, lycopene, lutein, and zeaxanthin. They are oil or fat-soluble colored complex found in fruits and vegetables. β-Carotene is typically present in foods that are radish-orange-green in colors, such as carrots, sweet potatoes, apricots, pumpkin, mangoes, and cantaloupe, as well as some green and leafy vegetables like collard greens, spinach, and kale. Lutein is abundant in green leafy vegetables such as collard greens, spinach, and kale[41]. Lutein is most known for its role in the defense of the retina against the harmful action of free radicals and also prevents atherosclerosis[42].

Polyphenols are a class of phytochemicals with notable antioxidant activity. Their antioxidant activity depends on their chemical and physical properties which, depending on their molecular structures, regulate the metabolism[43]. Phenolic acids, flavonoids, gingerol, and curcumin are among them[44]. Metal-Binding Proteins in Transport Metal-binding transport proteins such as albumin, ceruloplasmins, haptoglobin, and transferrin are found in human plasma and interact with transition metals to regulate the formation of metal-catalyzed free radicals. Albumin and ceruloplasmins are sequesters of copper ions, haptoglobins are sequesters of hemoglobin, and transferrin serves as the free iron sequester. Antioxidants that aren't proteins Non-protein antioxidants such as bilirubin, uric acids, and ubiquinol prevent oxidation by scavenging free radicals.[45] Fig. 1.2 are provided several specific forms of antioxidant structures.

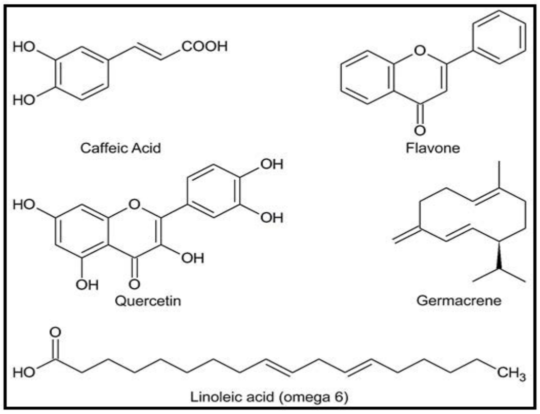

Fig. 2. 2. Structures of different natural antioxidants

Synthetic antioxidants are commercially generated or synthesized utilizing several techniques. They are primarily polyphenolic compounds that trap free radicals and resist chain reactions[46]. Some of these synthetic antioxidants are shown in Figure 2.4.

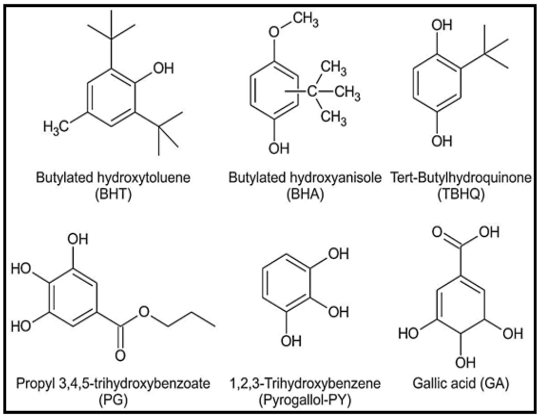

Fig. 2.3. Structures of different synthetic antioxidants

Working Mechanism of Antioxidants

Our immune cells use free radicals to fight bacteria, and our body must maintain a balance of free radicals and antioxidants. When food is converted into energy, free radicals are frequently produced. When hazardous metabolites exceed antioxidants, a situation known as oxidative stress develops. The DNA and other vital substances in our body will be destroyed by prolonged oxidative stress. It also frequently causes cell death. Harm to our DNA raises the chance of cancer, and several scientists have claimed that it plays a crucial role in the aging cycle. Psychological and environmental influences are believed to encourage unnecessary free radical development and oxidative stress. It is also increased by air emissions, tobacco smoking, alcohol consumption, heavy consumption of polyunsaturated compounds, radiation, including frequent sunbathing, bacterial, fungal, or virus diseases, frequent intake of mercury, magnesium, copper, or zinc, a severe and continuous activity that causes tissue injury, excessive intake of antioxidants such as vitamin C & E and antioxidant deficiency[46-47].

Extended oxidative stress contributes to elevated adverse health effects, such as chronic disease and other forms of cancer. Free radicals are only compounds containing one or two unpaired electrons. Electrons tend to be in groups, and unpaired electrons will contribute to unstable and extremely reactive molecules. To become stable, an electron must be given away the free radical. If a molecule loses an electron, the compound becomes oxidized and becomes a free radical[48].

The new free radical will deprive a new molecule of an electron and start a chain reaction. This mechanism constantly changes the structure of the molecules, resulting in irreparable damage. A free radical will grab a molecule electron which is then a free radical. But, if there is an antioxidant, the free radical will give an electron and stabilize it, avoiding the chain reaction as mentioned in Fig. 2.4, Instead of the other molecule, the antioxidant removes itself and turns into an open radical. But the antioxidant stabilizes the unpainted electron and is not highly reactive, unlike the majority of molecules. The antioxidant is disabled by this process[48].

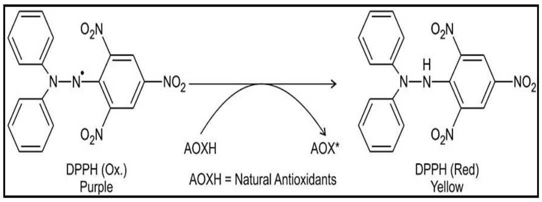

Fig. 2.4. General mechanism of antioxidant activity

Method for Analysis of Oxidant Activity

Antioxidant activity analysis techniques three primary techniques are primarily used in various specimens for antioxidant measurements. Chemical Antioxidant Assays are the first tool. Most chemical tests are used to determine the presence of antioxidants (herbal, nutraceutical, and food products) in products. The second approach is Biochemical Assays on Antioxidant Activity Analysis In biological models, i.e., Antioxidant behavior can also be evaluated in vivo and situ. These involve the analysis of the molecules including lipid, protein, DNA as well as other metabolites of oxidative stress markers for the ROS adduct or end-product. The third methods are Technical (Antioxidative) and Scientific methods. Antioxidant activity is measured using these methods. The oxygen radical absorption capacity (ORAC) test, for example, is one of the approaches. The Cupric Reducing Antioxidant Power (CUPRAC) test, the Ferric Reducing Antioxidant Power (FRAP) test, and the Folin-Ciocalteu test all involve a single electron transfer.The 2,2'-Azinobis-(3-ethylbenzothiazoline-6-sulfonic acid (ABTS) test and the [2,2-di(4-tert-octylphenyl)-1-picrylhydrazyl] (DPPH) test are both mixed assays that include the transfer of both a hydrogen atom and an electron. All of these tests are based on chemical processes, and spectrophotometry is used to analyze the kinetics or attain the equilibrium state, which requires the presence of specific colours or discoloration in the solutions to be tested. It can calculate the ability of antioxidant lyophilized vegetables, fruit drinks, drinks and water, bakery yeast, milk, tea, and coffee with a cholesterol-soluble antioxidant ability, and vegetable oils, salami extracts with an antioxidant solution[49].

Recent Status of Antioxidants and Its Importance

Synthetic chemicals applied to oxidization-prevention materials and natural compounds found in food and tissues. The former, synthetic antioxidants, are used for several purposes: they are used as food and beverage preservatives and are oxidation inhibitors in fuels[50]. The antioxidant characteristics of Nordihydroguaiaretic Acid were identified by Lundberg. This material is easily obtained from a specific plant (Larrea divaricata) in significant yields and favors comparisons with other highly efficient phenolic inhibitors[51-53].

The antioxidant function of compounds such as Delta-tocopherol, and Nordihydroguaiaretic acid in dairy products a significant number of phenolic compounds has been studied. Work has measured antioxidant function. Antioxidant behaviors were studied by Catherine Rice-Evans, Nicholas Miller, and George Paganga[54-58]. The antioxidant effects of polyphenols (vitamins E and C, as well as carotenoids) in fruit, vegetables, and red wine were partly attributed to their antioxidant capabilities. Recent research has demonstrated that many plant-derived polyphenolic nutritional constituents are more efficacious *In-vitro* antioxidants than vitamins E or C. The antioxidant activity of plant-derived flavonoids in the watery and lipophilic phases is currently known as well as the degree to which the activities of individual polyphenols can be linked to the total antioxidant potentials of wine and tea. Recent research teams demonstrate the role of an antioxidant in our first-line system of the body for superoxide dismutase (SOD), catalase (CAT), glutathione peroxidase (GPX), and catechins[59-60].

Antioxidant activity is being studied newly and interestingly. There has been a great deal of research to provide clear, accurate, and user-friendly analytical methods for the determination and assessment of food polyphenols by antioxidant potential (AOC). In the last twenty years, nanomaterials (NMs) are also part of the analytical chemistry field; in addition, NMs have opened up new avenues for developing analytical methods to improve research efficiency and sustainability, and become new instruments for food and drink quality control. Optical, electrical, and bio-electrochemical solutions to antioxidant materials have been identified by researchers. The key focus of the recorded research is the application of nanoparticles, quantum points, carbon nanomaterials, and polyphenol composite materials. Methods/devices that, in the opinion of the scientists, are advanced in fields of facility, speed, and usability have been the subject of the discussion. However, the quality of the implementation in real samples, besides the NMs, was given special attention. Methods/devices that, in the opinion of the scientists, are advanced in fields of facility, speed, and usability have been the subject of the discussion[61].

Many techniques for measuring the activity of antioxidants of any substance are created. Di-chloro-fluorescein as a fluorescent probe and azo compounds, including 2,2'-Azobis (2-amidinopropane) dihydrochloride (AAPH) as radical generators, are used as oxygen radically absorbing capacity (ORAC) process. It evaluates the peroxyl radical-induced oxidation inhibition caused by AAPH thermal breakdown.[62] The antioxidant potential of the material (foodstuffs) is calculated using the ABTS {2,2′-azino-bis, (3-ethylbenzothiazoline-6-sulfonic acid)}. ABTS test is also called Trolox equivalent antioxidant (TEAC) and is based on Arnao *et al.,* reporting process63. DPPH (1,1′-diphenyl-2-picrylhydrazyl) assay is carried out as per the reported method of Brand-Williams *et al.,*[64] The TBARS method is used to determine the degree of lipid peroxidation in a sample. TBARS is the reaction product of thiobarbituric acid (TBA) and malondialdehyde (MDA), which occurs from the degradation of lipid hydroperoxide in the sample at 532 nm.[65] SOD is assessed using Kakkar *et al.,* technique which uses nicotinamide adenine dinucleotide (NADH) as a substrate.[66]

Total antioxidant capacity (TAC) is a regularly used analyte to assess the antioxidant status of biological samples and can be used to determine.

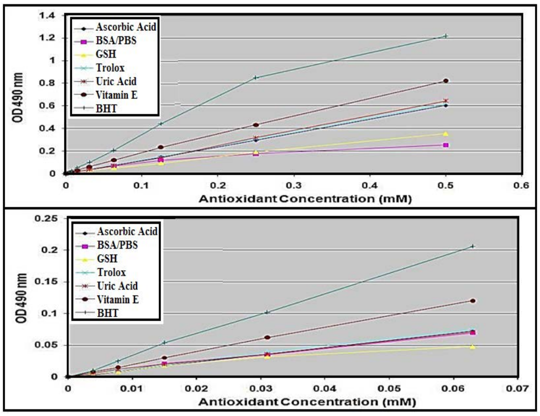

Fig. 3.1. Antioxidant TAC Assay with Various Antioxidants[67]

The antioxidant response against the free radicals produced in a given disease. Some graphs show a comparative study of the TAC value for antioxidants[67].

One more interesting quality feature being studied by researchers is ORAC which means Oxygen Radical Absorbance Capacity. ORAC tests how many radicals of oxygen can be consumed by a certain substance. The higher the ORAC score, the better it can help our body fight diseases such as cancer and heart disease. more and more ORAC score68the more it can be used to fight food disease. ORAC and its meaning are mainly synonymous with antioxidants. ORAC values are shown by graphs for such compounds Figure 3.2.

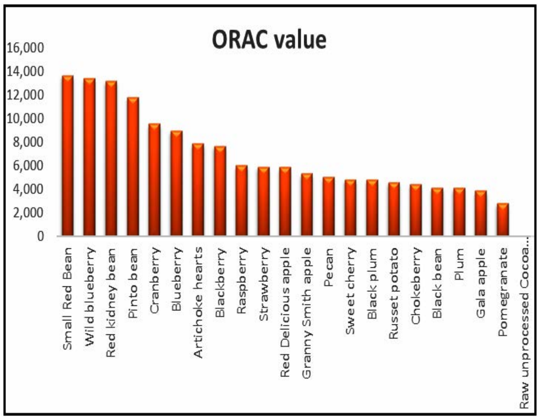

Fig. 3.2. ORAC values of different food material[68]

Many experiments in free radicals, oxidative stress, and antioxidant activity of food have been carried out which give antioxidants a significant benefit, yet many researchers have recently questioned their importance and tried to understand the processes behind oxidation stress. Many scholars argue that absorption is very small regardless of the number of antioxidants ingested and, in some cases, prooxidants are good for human health. A wide variety of different analyses, all with advantages and inconveniences, can detect antioxidant activity and common antioxidant compounds[69].

CONCLUSION

To counter the negative effect of biochemical oxidative stress developed by the composition of reactive oxygen species, the body always maintains an antioxidant defense system. A major factor in the production of several pathological diseases is oxidative stress.[69] A large number of reactive species resulting in metabolic functions are generated in the body. These active oxygen species are important for life as they are responsible for many physiological processes, such as energy generation, basic compound synthesis, and signal transduction. As source materials of antioxidants, global interest in food and food supplements grows, because there is growing evidence of the importance of antioxidants for health and the prevention of diseases. This research explored many processes that could correspond to the antioxidant activity in foodstuffs and which could play a significant nutrient role in the diet of both children and young adults in certain of the world's worst regions (India and Sub-Saharan Africa). The antioxidant activity in phenolic material was equivalent to black tea, except for the iron chelation, which was roughly Fourteen times stronger. Doum palm fruit has less antioxidant activity as a bulk than black tea, possibly because of the high sugar content in the fruit extract. However, is often compared to various food sources, such as potato peels, honey, and quince fruits are rich in antioxidants[70-72]. Nevertheless, the antioxidant activity in phenolic material was equivalent to black tea, except for the iron chelation, which was roughly Fourteen times stronger.

ACKNOWLEDGEMENT

Auther are thankful to Jai Narain Vyas University Jodhpur, Rajasthan, India for providing laboratory facility.

Conflict of interest

All authors approve the final manuscript and declare that there is no conflict of interest.

REFERENCES

1. Halliwell, B; Gutteridge, J.M.C. *OUP*., **1989.**
2. Dittrich, M. A.P., *San Francisco.,* **1977**, 999–1015.
3. Wagenitz, G.; Hellwig, F. H., *RBGK.,* **1996**, 491–510.
4. Bancheva, S.; Greilhuber, *J. Plant Syst. Evol.* **2006**, *257*, 95-117
5. Davis, P.H. *EUP.,* **1988**, *10.*
6. Guner, A.; Ozhatay, N.; Ekim, T.; Baser, K.H.C. *EUP*., **2000.**
7. Kargıoglu, M.; Cenkci, S.; Serteser, A.; Evliyaoglu, N.; Konuk, M.; Kok, M.S.; Bagcı, Y. *Hum. Ecol.*, **2008**, *36*, 763-777
8. Sezik, E.; Yesilada, E.; Honda, G.; Takaishi, Y.; Takeda, Y.; Tanaka, T. *J. Ethnopharmacol.*, **2001**, *75*, 95–115.
9. Honda, G.; Yesilada, E.; Tabata, M.; Sezik, E.; Fujita, T.; Takeda, Y.; Takaishi, Y.; Tanaka, T. *J. Ethnopharmacol.*, **1996**, *53*, 75–87.
10. Zengin, G.; Cakmak, Y.S.; Guler,G.O.; Aktumsek, A. *Food Chem. Toxicol.*, **2010**, *48*, 2638-41.
11. Sarker, S.D.; Kumarasamy, Y.; Shoeb, M.; Celik, S.; Yucel, E.; Middleton, M.; Nahar, L., Opem., **2005**, *5*, 246-250.

12. Tepe, B.; Sokmen, M.; Akpulat, H.A.; Yumrutas, O.; Sokmen,A., *Food Chem.*, **2006**, *98*, 9-13.
13. Tekeli, Y.; Sezgin, M.; Aktumsek, A.; Guler, G.O.; Sanda M.A. *Nat. Prod. Res.*, **2010**, *24*, 1883-1889.
14. Yildirim, N.; Sunar, S.; Agar, G; Bozari, S.; Aksakal O. *Biochem. Genet.*, **2009**, *47*, 850-859.
15. Saha, M.N.; Alam, M.A.; Aktar, R.; Jahangir, R. *Bangladesh J. Pharmacol.*, **2008**, *3*, 90-96.
16. Makari, H.K.; Haraprasad, N.; Patil, H.S.; Ravikumar. *The Internet J. Aesthetic and Antiaging Medicine.,* **2008**, *1*, 1-10.
17. Augustin, S.; Claudine, M.; Christine, M.; Christian, R. *Crit. Rev. Food Sciences .,* **2005**, *45*, 287-306.
18. Aviram, M. *Free Rad. Res.*, **2000**, *33*, S85-S87.
19. Polterait, O. *Current Org. Chem.,* **1997**, *1*, 415-440.
20. Singh, G.; Rao, G.P.; Kapoor, P.S.; Singh, O.P. *J. MedAromat Plants.*, **2000**, *22*, 701-708.
21. Wu, Q. P.; Wang, Z. J.; Tang, L. Y.; Fu, M. H.; He, Y. *Chin. Chem. Lette.*, **2008**, *2*, 321.
22. Hayashi, S.; Yoshida, A.; Tanaka, H.; Mitani, Y.; Yoshizawa, K. *Chem. Pharma. Bull .,* **1980**, *28*, 406-412.
23. Siddique, I.; Anis, M; Aref, I. M. *Applied Biochem and Biotechnol.,* **2010**, *162*, 2067-2074.
24. Parveen, S.; Shahzad, A. *Acta Physiol Plant.,* **2011**, *23*, 789-796.
25. Silva, C. R.; Monteiro, M. R.; Rocha, H. M.; Ribeiro, A. F., Caldeira-de-Araujo, A.; LeitãoA. C.; Bezerra, R. J. A. C.; Pádula, M. *Toxicol in Vitro.*, **2008**, *22*, 212-218.
26. Arya, R. *Bioresour Techno.,* **2003**, *86*, 165-169.
27. Doi, K.; Kojima, T.; Makino, M.; Kimura, Y.; Fujimoto, Y. *Chem. Pharmacol Bull.*, **2001**, *49*, 151–153.
28. Alma, M. H.; Nitz, S.; Kollmannsberger, H.; Digrak, M.; Efe, F. T.; Yilmaz, N. *J. Agric. Food Chem.*, **2004**, *52*, 3911-3914.
29. Giner-Larza, E. M.; Manez, S.; Giner, R. M.; Recio, M. C.; Prieto, J. M.; Cerda-Nicolas, M.; Rios, J. L. *Planta Med.*, **2002**, *68*, 311-315.
30. Giner-Larza, E. M.; Manez, S.; Recio, M. C.; Giner, R. M.; Prieto, J. M.; Cerda-Nicolas, M.; Rios, J. L. *Eur. J. Pharmacol.*, **2001**, *428*, 137-143.
31. Duru, M. E.; Cakir, A.; Kordali, S.; Zengin, H.; Harmandar, M.; Izumi, S.; Hirata, T. *Fitoterapia.,* **2003**, *74*, 170-176.
32. Koutsoudaki, C.; Krsek, M.; Rodger, A. chia. *J. Agric. Food Chem.*, **2005**, *53*, 7681-7685.
33. Ozcelik, B.; Aslan, M.; Orhan, I.; Karaoglu, T. *Microbiol. Res.*, **2005**, *160*, 159-164.
34. Orhan, I.; Kupeli, E.; Aslan, M.; Kartal, M.; Yesilada, E. *J. Ethnopharmacol.*, **2006**, *105*, 235-240.
35. Romani, A.; Pinelli, P.; Galardi, C.; Mulinacci, N.; Tattini, M *Phytochem. Anal.*, **2002**, *13*, 79-86.
36. Baratto, M. C.; Tattini, M.; Galardi, C.; Pinelli, P.; Romani, A.; Visioli, F.; Basosi, R.; Pogni, R. *Free Radical Res.*, **2003**, *37*, 405-412
37. Kivcak, B.; Akay, S. *Fitoterapia.,* **2005**, *76*, 62-66.
38. Chakraborty, P.; Kumar, S.; Dutta, D.; Gupta, V. *Res J Pharm Technol.*, **2009**, *2*, 238–244.
39. Hissin, PJ.; Hilf, R. *Anal Biochem.*, **1976**, *74*, 214–226.
40. Reagan, V.; Rahimi, Z.; Zahraie, M.; Noroozian, M.; Pourmotabbed, A. *Acta Med Iran.,* **1976**, *45*, 271–276.
41. Hamid, AA.; Aiyelaagbe, OO.; Usman, LA.; Ameen, OM.; Lawal A. *Afr J Pure Appl Chem.*, **2010**, *4*,142–151.
42. Sikora, E.; Cieslik, E.; Topolska, K. *Acta Sci Pol Techno Aliment.*, **2008**, *7*, 5–17.
43. Ajila, CM.; Brar, SK.; Verma, M.; Tyagi, RD.; Godbout, S.; Valéro, JR. *Crit Rev Biotechnol.*, **2011**, *31*, 227–249.
44. Amit, K; Priyadarsini, KI. *J Med Allied Sci.*, **2011**, *1*, 53–60.
45. Papas, AM. CRC Series, Boca Raton, FL., **1998**, 672.
46. Gupta, VK.; Sharma, SK. *Nat. Prod. Radiance.*, **2006**, *5*, 326–334.
47. Lobo, V.; Patil, A.; Phatak, A.; Chandra, N. *Pharmacogn Rev.*, **2010**, *4*, 118–126.
48. Kurutas, E. B. *Nutrition journal.,* **2016**, *15*, 71. https://doi.org/10.1186/s12937-016-0186-5.
49. (http://www.selectscience.net/product-news/rapid-andaccurate-antioxidant-measurement-in-foods).
50. Dabelstein, W.; Reglitzky, A.; Schütze, A.; Reders, K. Ullmann's Encyclopedia of Industrial Chemistry., **2007.**
51. Lundberg, W.O.; Halvorson, H.O.; Burr, G.O. *Oil Soap.*, **1944**, *21*, 33–35 https://doi.org/10.1007/BF02593156.
52. W. B. Esselen Jr. shows antioxidant activity in d-Isoascorbic Acid.

53. W. B. Esselen Jr.J. *J. Powers R. Woodward Ind. Eng. Chem*., **1945**, *37*, 3, 295-299 https://doi.org/10.1021/ie50423a023.
54. Griewahn, J.; Daubert, B.F. *J. Am. Oil Chem. Soc.,* **1948**, *25*, 26-27 doi:10.1007/BF02553638.
55. Stull, J.W.; Herreid, E.O.; Tracy, P.H. *J. Dairy Sc*., **1948**, *31*, 449-454 https://doi.org/10.3168/jds.S0022-0302(48)92228-0.
56. Budowski, P. *J. Am. Oil Chem. Soc*., **1950**, *27*, 264-267.
57. Lips, H. J.; McFarlane, W.D. *Can. J. Res*., **1950**, *28*, 157-165.
58. Rice-Evans, C.; Miller, N.; Paganga, G. *Trends plant Sci*., **1997**, *2*, 152-159.
59. Ighodaro, O.M.; Akinloye, O.A. *Alexandria J. Med*., **2018**, *54*, 287-293.
60. Michalina, Grzesik.; Katarzyna, Naparło.; Grzegorz, Bartosz.; Izabela Sadowska-Bartosz. *Food Chem*., **2018**, *241*, 480-492https://doi.org/10.1016/j.foodchem. 2017.08.117.
61. Della Pelle, F.; Compagnone, D. *Food. Sensors.,* **2018**, *18*, 462.
62. Čiž, M.; Čížová, H.; Denev, P.; Kratchanova, M.; Slavov, A.; Lojek, A. *Food Control*., **2010**, *21*, 518–523.
63. Arnao, MB.; Cano, A.; Acosta, M. *Food Chem.,* **2001**, *73*, 239–244.
64. Brand-Williams, W.; Cuvelier, ME.; Berset, C. *Lebensm Wiss Technol*., **1995**, *28*, 25–30.
65. Ohkawa, H.; Oishi, N.; Yagi, K. *Anal Biochem*., **1979**, *95*, 351–358.
66. Kakkar, PS.; Das, BB.; Viswanathan, PN. *Indian J Biochem. Biophys*., **1984**, *21*, 130–132.
67. https://www.cellbiolabs.com/total-antioxidant-capacity-tac-assay.
68. https://en.wikipedia.org/wiki/ORAC.
69. Márcio, Carocho.; Isabel, C.F.R. Ferreira. *Food Chemi Toxicol*., **2013**, *51*, 15-25.https://doi.org/10.1016/j.fct.2012.09.021.
70. Nandita, S.; Rajini, P.S. *Food Chem.,* **2004**, *85*, 611–616.
71. Aljadi, A. M.; Kamarudin, M. Y. *Food Chem.,* **2004**, *85*, 513–518.
72. Silva, B. M.; Andrade, P.B.; Valentao, P.; Ferreres, F.; Seabra, R. M.; Ferreira, M. A. *J. Agric. Food Chem*., **2004**, *52*, 4705–4712.