Journal of Chemical Health Risks

www.jchr.org

JCHR (2023) 13(4), 741-746 | ISSN:2251-6727

Review of the Antioxidant Properties and Nutritional Factors of Lemons

Pranab Paul[1], Bijoy Neog[2]

[1]Department of Botany Dibru College Dibrugarh, Assam-786003

[2] Department of Life Sciences Dibrugarh University Dibrugarh, Assam-786001

(Received: 02 September 2023 Revised: 14 October Accepted: 07 November)

KEYWORDS
Lemon,
Phytochemicals,
Antioxidants

ABSTRACT:
Lemon is a widely cultivated fruit and is said to have its origin in North-East India is known for its refreshing flavour and high vitamin C content. There are many varieties of lemon which is seen growing either wild, cultivated or in homestead gardens in this part of the country. In addition to its nutritional value, lemon has been recognized for its potential health benefits due to its antioxidant activity. Antioxidants play a crucial role in protecting the body against oxidative stress, which has been associated with various chronic diseases. This review aims to provide an overview of the antioxidant activity of lemon, exploring its major phytochemical composition.

Lemon plants belong to the family Rutaceae, genus *Citrus* encompassing small to medium-sized shrubs or trees adorned with sharp axillary spines. According to Iwamasa (1976), the Citrus genus originated approximately thirty to forty million years ago in the vicinity of Assam, India. The term lemon is used as to the way it is referred in North-east India particularly Assam. Bira jora and the mitha jora are varieties of *Citrus medica*, Assam lemon, pati nemu, jora tenga, godha pati nemu, elaichi nemu are varieties of *Citrus limon*, rough lemon *Citrus jambhiri* and kaghzi nemu *Citrus aurantifolia* are the different types of lemon prevalent in North East India. Kaghji nemu shows variation in having yellow to orange pulp and white pulp and also varying in taste and aroma.

Lemon is a highly versatile fruit with both culinary and medicinal applications. It is primarily consumed fresh or as juice, providing a refreshing beverage option during hot summer days. In Assam, people also prepare prickles from lemon. Lemon juice is commonly paired with rice and curry and features prominently in certain ethnic dishes.

Furthermore, Citrus is an ethnobotanically significant plant utilized by the local population in Assam for treating various ailments. For instance, tender leaves of Golnemu (*Citrus aurantifolia*) are used to treat diarrhoea (Borah et al., 2006). Ripe fruits of Bira jora (*Citrus medica* Linn.) are employed for sore throats, coughs, asthma, and numerous other health concerns. Citrus extracts exhibit potent antioxidant activity and antiulcer properties, adding to their medicinal appeal (Nagaraju et al., 2012). Beyond their nutritional value, Citrus fruits contain phenols, flavonoids, and limonoids, which have anti-carcinogenic, anti-inflammatory, and anti-allergic properties (Manthey et al., 2000). Moreover, they are recognized for their vitamin E (a-d Tocopherol) content, contributing to their overall health-promoting attributes (Newhall and Ting, 1965; Ting and Newhall, 1965).

Citrus is a versatile fruit with a rich history, culinary significance, valuable medicinal properties and high antioxidant activity. Its global production and range of health benefits make it a noteworthy component of both our diet and our pursuit of improved well-being.

Oxidative stress is a physiological condition that occurs when there is an imbalance between the production of reactive oxygen species (ROS) and the body's ability to detoxify or repair the resulting damage. ROS, such as superoxide anion, hydrogen peroxide, and hydroxyl radical, are natural by-products of cellular metabolism and are also generated in response to external factors such as pollution, radiation, and toxins.

While the body has natural defence mechanisms against ROS, excessive production or impaired antioxidant systems can lead to an accumulation of ROS and subsequent oxidative stress. Oxidative stress can damage lipids, proteins, and DNA, leading to cellular dysfunction and contributing to the development and progression of various diseases in human beings. Cardiovascular disease, diabetes, neurodegenerative disorders (such as Alzheimer's and Parkinson's diseases), cancer, and is also considered a significant factor in the aging process. ROS are also involved in immune responses, playing a role in defence against pathogens. However, excessive ROS production can lead to immune dysfunction, chronic inflammation, and autoimmune disorders. ROS can cause DNA damage, including modifications to the DNA structure and

Journal of Chemical Health Risks
www.jchr.org
JCHR (2023) 13(4), 741-746 | ISSN:2251-6727

mutations. This damage can disrupt normal cellular processes and potentially contribute to the development of cancer.

Antioxidants are molecules that can neutralize ROS and protect against oxidative stress. According to Halliwell and Gutteridge's (1989) definition, antioxidants are substances that, when found in relatively small quantities compared to an oxidizable substrate, effectively impede or postpone the oxidation of that particular substance. The body has an endogenous antioxidant defence system that includes enzymes (such as superoxide dismutase, catalase, and glutathione peroxidase) and non-enzymatic antioxidants (such as vitamins C and E, glutathione, and polyphenols). Maintaining a balance between ROS production and antioxidant defence is crucial for maintaining cellular homeostasis and reducing the risk of oxidative stress-related diseases.

Understanding the implications of oxidative stress for human health has led to increased interest in identifying natural antioxidants from dietary sources, such as fruits and vegetables. Lemon, with its high content of antioxidant compounds, has gained attention for its potential to mitigate oxidative stress and promote health. Further research is needed to explore the specific mechanisms by which lemon and its antioxidants exert their protective effects and their potential applications in disease prevention and management.

Overview of the major phytochemicals found in lemon

Lemon juice contains several phytochemicals, which are natural bioactive compounds. The major phytochemicals are phenols, flavonoids, reducing sugars, steroids, terpinedes, tannins, Ascorbic Acid, Citric Acid, Flavonoids, Limonoids, Pectin, D-limonene, Coumarins and different mineral nutrients.

Janati et al. (2012), lemon peels were analysed as potential foodstuffs to determine their nutritional composition and chemical parameters. The study focused on crude protein, phosphorus, calcium, copper, manganese, iron, zinc, sodium, potassium, as well as certain chemical parameters in feedstuffs.

Lemon fruits are a good source of potassium, an important mineral that helps regulate blood pressure, fluid balance, and muscle contractions. Calcium though not as abundant as in dairy products, lemons contain some calcium, which is essential for healthy bones and teeth, as well as muscle function and nerve transmission. Lemons contain small amounts of magnesium, which is involved in hundreds of biochemical reactions in the body and is important for muscle and nerve function, blood sugar regulation, and bone health. Phosphorus is another mineral present, albeit in smaller amounts. It plays a role in bone health, energy metabolism, and various cellular processes. Copper is a trace mineral found in lemon. It is essential for the formation of red blood cells, connective tissues, and the functioning of enzymes. While lemons are not particularly high in iron, they do contain some non-haem iron, which is less easily absorbed by the body compared to haem iron found in animal sources. Nonetheless, the vitamin C in lemon can enhance the absorption of non-haem iron. Lemons also contain small amounts of zinc, which is necessary for immune function, wound healing, and DNA synthesis. Manganese is present in Lemon at low levels and is involved in bone formation, blood clotting, and the metabolism of amino acids, cholesterol, and carbohydrates. Sulphur is found in the form of sulphur-containing compounds in citrus fruits, and it is essential for the structure of proteins and enzymes. The sodium content in lemon is negligible and can be useful to specific dietary conditions involving low sodium intake. These are the major minerals found in lemon but it should be noted that the mineral content can vary depending on the specific type of lemons and its growing conditions.

The mineral content of lemon juice is tabled below.

Mineral	**Amount/100g Juice**
Calcium, Ca	6mg
Iron, Fe	0.08 mg
Magnesium, Mg	6 mg
Phosphorus, P	8 mg
Potassium, K	103 mg
Sodium, Na	1 mg
Zinc, Zn	0.05 mg
Copper, Cu	0.016 mg

Journal of Chemical Health Risks
www.jchr.org
JCHR (2023) 13(4), 741-746 | ISSN:2251-6727

Manganese, Mn	0.012 mg
Selenium, Se	0.1 mg

Source: Data Type: U.S. DEPARTMENT OF AGRICULTURE SR Legacy Food Category: Fruits and Fruit Juices FDC ID: 167747 NDB Number:9152 FDC Published:4/1/2019

Citrus plants are attributed to the presence of diverse phytochemicals in them. In the study conducted by Suja et al. (2017), the lemon samples analysed exhibited the presence of primary metabolites such as carbohydrates and proteins. Interestingly, the researchers observed the unique presence of saponin solely in the ethanolic extract of the sample.

A similar investigation by Rana and Dixit (2017) revealed positive results for steroids, tannins, phenols, carbohydrates, flavonoids, and alkaloids, while sulphates and proteins were absent. Additionally, Namani et al. (2014) conducted a study on *Citrus aurantifolia L.* leaves grown in two regions of Oman. Their analysis indicated the significant presence of carbohydrates, tannins, alkaloids and steroids. However, the experiment did not yield positive results for saponins and proteins in the leaf samples. Studies revealed that lemon juice may have a lower concentration of cardiac glycosides compared to other citrus fruits.

Though lemon fruits are generally sour but they contain different types of sugar. Lemon fruits, like many other fruits, naturally contain sugars, primarily in the form of fructose, glucose, and sucrose. Asencio et al. (2018) found sugar content can vary slightly depending on the specific type and ripeness of the citrus fruit.

Fructose is a natural fruit sugar and is the most common type of sugar found in citrus fruits. It has a sweet taste and is the primary sugar responsible for the sweet flavour of these fruits. It has been found that vitamin C content in *Citrus* decreases as its fructose content increases. This reduction in vitamin C potency can be attributed to a reaction that occurs between the carbonyl groups of fructose and vitamin C.

Glucose is another simple sugar found in citrus fruits. It is less prevalent than fructose but still contributes to the overall sweetness of the fruit.

Sucrose is a disaccharide sugar composed of one molecule of glucose and one molecule of fructose linked together. It is also present in citrus fruits, although in smaller amounts compared to fructose.

Other Sugars: In addition to fructose, glucose, and sucrose, citrus fruits may contain small amounts of other sugars, such as maltose and xylose, but these are typically present in very minor quantities.

Sugar	Amount per 100g of juice.
Carbohydrate	6.9 g
Sucrose	0.43g
Glucose	0.99g
Fructose	1.1g

Source: LEMON JUICE, RAW (SR LEGACY, 167747) Data Type: U.S. DEPARTMENT OF AGRICULTURE SR Legacy Food Category: Fruits and Fruit Juices FDC ID: 167747 NDB Number:9152 FDC Published:4/1/2019

Additionally, lemons provide a wide range of essential nutrients, including vitamins, minerals, and dietary fibre, making them a nutritious choice as part of a balanced diet.

Antioxidants in lemon

Lemon juice, derived from the citrus fruit lemon (*Citrus limon*), has long been recognized for its tangy taste and versatile culinary uses. Beyond its refreshing flavour, lemon juice has gained attention for its potential health benefits, particularly as a rich source of antioxidants.

Flavonoids are a class of plant compounds known for their antioxidant and anti-inflammatory effects. Lemon juice contains several flavonoids, such as hesperidin, eriocitrin, and narirutin, which have demonstrated strong antioxidant activity. These flavonoids scavenge free radicals, reduce oxidative damage, and provide potential health benefits. In the research conducted by Miyake et al. (1997a, 1997b), the isolation and identification of antioxidative flavonoid glycosides from lemon fruit were investigated. They identified eriocitrin (eriodictyol-7-rutinoside), a flavanone glycoside, and 6,8-di-C-~-glucosyldiosmin (DGD) and 6-C-p-glucosyldiosmin (GD), which are C-glucosyl flavones. Lipid peroxidation, a major factor contributing to the deterioration of foods during storage and processing, was found to be inhibited by the antioxidants found in

JCHR (2023) 13(4), 741-746 | ISSN:2251-6727

lemon fruit (Miyake et al., 1997a). Additionally, two more antioxidative flavonoid glycosides, neoeriocitrin (eriodictyol-7-rhamnoglucoside) and narirutin (naringenin ~-7-rutinoside), were isolated from the peel extract of lemon fruit. The HPLC profile of the antioxidative flavonoid fraction depicted the flavonoid compounds, including naringin (naringenin p-7-rhamnoglucoside), hesperidin (hesperetin ~-7-rutinoside), and diosmin (diosmetin p-7-rutinoside). In total, nine flavonoid glycosides were identified in the antioxidative flavonoid fraction of lemon peel extract (Miyake et al., 1997b). Eriocitrin exhibited the strongest antioxidative activity among the flavonoid glycosides found in lemon fruit, while neoeriocitrin and DGD also demonstrated antioxidative activity, although the remaining compounds displayed only weak activity. These findings suggest that the antioxidants present in lemon fruit may provide protection against peroxidative damage in living systems (Miyake et al., 1997b). Furthermore, the content of flavonoid compounds in lemon juice was examined in relation to different methods of squeezing the fruit. The content of eriocitrin and hesperidin was found to be higher in lemon juice obtained using an in-line extractor compared to hand squeezing. It was concluded that the in-line extractor method, which applies higher pressure to the fruit and may include pulps from the albedo and pulp vesicle, resulted in higher levels of eriocitrin and hesperidin in the juice. This method is commercially important for maximizing juice yield (Miyake et al., 1997b). Moreover, the distribution of flavonoid compounds from the peel and juice of citrus fruits was investigated. Eriocitrin, DGD, and GD were found in both lemons and limes, but in minimal amounts in other types of citrus fruits. Neoeriocitrin was particularly abundant in daidai, while eriocitrin and GD were plentiful in lemon and lime fruits, especially in the peel obtained as a byproduct from juice factories (Miyake et al., 1997b). In the study by González-Molina and Moren (2012), the phytochemical quality of Fino lemon juice (Citrus limon (L.) Burm. F.) for industrial use was assessed. The main human-health-related phytonutrients identified in lemon juice were hesperidin and eriocitrin (flavanones), along with small amounts of diosmetin glycosides (flavones). Other flavonoids detected in lemon juice included vicenin-2, iso/limocitrol 3- -glucoside. To get a comprehensive idea of the different flavonoids present in lemon and lime this table is given.

Fruit description	**Subclass**	**Flavonoid**	**(mg/100 g fresh weight)**
Lemons, raw, without peel	Flavanones	Eriodictyol	21.36
Hesperetin	27.90		
Naringenin	0.55		
Flavones	Apigenin ND Luteolin	1.90	
Flavonols	Kaempferol	0.03	
Myricetin	0.50		
Quercetin		1.14	
Lemon juice, raw	Flavanones	Eriodictyol	4.88
Hesperetin	14.47		
Naringenin	1.38		

Source: USDA Database for the Flavonoid Content of Selected Foods, Release 3.0, 2011b.

Vitamin C, also known as ascorbic acid, is abundant in lemon juice. It is a powerful water-soluble antioxidant that plays a crucial role in neutralizing free radicals and regenerating other antioxidants in the body. Lemon juice is an excellent source of vitamin C, which contributes to its overall antioxidant capacity. The mineral composition of the soil in which lemons are cultivated plays a crucial role in determining the vitamin C content found in the fruit juice. Specifically, certain minerals exhibit significant effects. Nitrogen and phosphorous, when present in excess of their optimum levels, can have adverse effects on vitamin C content. Conversely, an increased concentration of potassium in the soil has been observed to result in higher vitamin C content in the lemons. Additionally, temperature is a key factor influencing vitamin C production, with hot temperatures having an adverse impact. Nevertheless, exposure of the fruit to sunlight has been associated with an increase in vitamin C content, highlighting the multifaceted interplay of environmental factors in determining the nutritional quality of lemons. In

Journal of Chemical Health Risks
www.jchr.org
JCHR (2023) 13(4), 741-746 | ISSN:2251-6727

a study conducted by Paul (2016), the vitamin C content of various Citrus fruits in the Dibrugarh district of Assam was analysed. The study revealed that the jora tenga variety (*Citrus limon*) had the highest vitamin C content per 100 cc of juice, followed by the bira-jora variety (*Citrus medica*), and then the kaji nemu variety (*Citrus limon*).

Sl. No.	**Lemon**	**IC50 value (µg/ml)**
1	*C. jambhiri* Lush.	11.81
2	*C. limon (L.)* Osbeck	13.45
3	*C. aurantifolia (Christm.)* Swingle	11.41
4	*C. jambhiri* Lush.	10.4
5	*C. assamensis* R. M. Dutta and Bhattacharya	7.52
6	*C. medica* L.	8.58

Vitamin C content in some lemon varieties Table source: Jyoti et al. (2023)

Limonoids, another group of phytochemicals found in lemon juice, exhibit antioxidant properties as well. These compounds have been studied for their potential anticancer effects and their ability to protect against oxidative stress-related diseases.

Polyphenols, including caffeic acid, ferulic acid, and coumarins, contribute to its antioxidant activity. These polyphenols possess diverse biological properties and have been associated with a lot of health benefits.

Lemon juice is a readily available and affordable source of antioxidants, making it an attractive addition to a balanced diet. It can be enjoyed on its own as a refreshing beverage or used as a flavour enhancer in various culinary preparations, such as salad dressings, marinades, and beverages. The potential health benefits of lemon juice's antioxidant activity are numerous. Regular consumption of lemon juice or incorporation of lemon juice into the diet may help reduce the risk of chronic diseases, enhance immune function, support cardiovascular health, and promote healthy aging. North-east India particularly Assam being a hotspot of lemon diversity a lot of work need to be done particularly the quantitative aspect of the nutraceutical and antioxidants. Also, extensive in vivo tests have to be carried out evaluating the antioxidant capacity of lemon extracts. Work can also be done to study lemon's free radical scavenging activity and its impact on oxidative stress markers.

In conclusion, lemon possesses significant antioxidant activity, attributed to its diverse phytochemical composition. The review highlights the potential health benefits of lemon's antioxidant effects and emphasizes the need for further research to fully elucidate the mechanisms underlying its protective properties. Understanding the antioxidant activity of lemon could have implications for developing dietary strategies and functional foods aimed at preventing oxidative stress-related diseases.

References

1. Asencio, A. D., Serrano, M., García-Martínez, S., & Pretel, M. T. (2018). Organic acids, sugars, antioxidant activity, sensorial and other fruit characteristics of nine traditional Spanish citrus fruits. *European Food Research and Technology*, *244*(8), 1497-1508. https://doi.org/10.1007/s00217-018-3064-x
2. Halliwell, B., & Gutteridge, J. M. (1990). The antioxidants of human extracellular fluids. *Archives of Biochemistry and Biophysics*, *280*(1), 1-8. https://doi.org/10.1016/0003-9861(90)90510-6
3. Borah,P.K., Gogoi,P., Phukan, A.C., & Mahanta, J. (2006). Traditional medicine in the treatment of gastrointestinal diseases in Upper Assam. *Indian Journal of Traditional Knowledge 5*(4),510 – 512.
4. Halliwell, B., & Gutteridge, J. M. (1990). The antioxidants of human extracellular fluids. *Archives of Biochemistry and Biophysics*, *280*(1), 1-8. https://doi.org/10.1016/0003-9861(90)90510-6
5. González-Molina, E., Gironés-Vilaplana, A., Mena, P., Moreno, D. A., & García-Viguera, C. (2012). New beverages of lemon juice with elderberry and grape concentrates as a source of Bioactive compounds. *Journal of Food Science*, *77*(6). https://doi.org/10.1111/j.1750-3841.2012.02715.x
6. Ichado A.S.P., & Ayeni, M.B. (2020). Protein and mineral composition of some fruit juices (Citrus

Journal of Chemical Health Risks

www.jchr.org

JCHR (2023) 13(4), 741-746 | ISSN:2251-6727

cinesis Spp) in some selected areas in Lokoja metropolis. *International Journal Advance Multidiscipline Research 7*(6), 22-26. DOI: http://dx.doi.org/10.22192/ijamr.2020.07.06.003

7. Janati, S. S. F., Beheshti, H. R., Feizy, J., & Fahim, N. K. (2012). Chemical composition of lemon (Citrus limon) and peels its considerations as animal food. *Gida*, *37*(5), 267-271.
8. Jyoti, S. Y., Kalita, I., & Tanti, B. (2023). Phytochemical screening, proximate composition and antioxidant activities of Citrus germplasm of Assam, India. *Vegetos*, 1-13.
9. Manthey, J.A., Grohmann, K., & Manthey, C.L. (2000) Anti-inflammatoryproperties of citrus flavonoids. *International Citrus Congress*, 71: 61.
10. MIYAKE, Y., YAMAMOTO, K., MORIMITSU, Y., & OSAWA, T. (1998). Characteristics of Antioxidative flavonoid glycosides in lemon fruit. *Food Science and Technology International, Tokyo*, *4*(1), 48-53. https://doi.org/10.3136/fsti9596t9798.4.48
11. Nagaraju, B., Anand, S. C., Ahmed, N., Chandra, S.N.J.N., Ahmed, F., & Padmavathi, G.V. (2012) Antiulcer activity of aqueous extract of Citrus medica Linn. fruit against ethanol induced ulcer in rats. *Advances in Biological Research 6*(1), 24 – 29.
12. Namani, J., Baqir, E., Al Abri, A., Al Hubaishi, T., Husain, A., & Khan, S. A. (2018). Phytochemical screening, phenolic content and antioxidant activity of Citrus aurantifolia L. Leaves grown in two regions of oman. *Iranian Journal of Pharmaceutical Sciences*, *14*(1), 27-34.
13. Newhall, W.F., and Ting, S.V. (1965) Isolation and identification of α- tocopherol, a vitamin E factor from orange flavedo. *Journal of Agricultural and Food Chemistry*, *13*,281-282.
14. Paul P (2016) Vitamin C content in some Citrus fruits of Dibrugarh district, Assam. *Khoj, Vol VIII*, 50-58.
15. Pham, T., Nguyen, N. T., Dinh, D. V., Kieu, N. T., Bach, L. G., Phong, H. X., Muoi, N. V., & Truc, T. T. (2020). Evaluate the chemical composition of peels and juice of seedless lemon (*Citrus latifolia*) grown in Hau Giang province, Vietnam. *IOP Conference Series: Materials Science and Engineering*, *991*(1), 012127. https://doi.org/10.1088/1757-899x/991/1/012127
16. Rana, S., Dixit, S., & Mittal, A. (2017). Anticancer effects of chemotherapy and nature products. *Journal of Medical Discovery*, *2*(2), 1-8.
17. Steven Nagy (1980). Vitamin C contents of citrus fruit and their products: a review. *Journal of* Agricultural and Food Chemistry 28 (1), 8-18.DOI: 10.1021/jf60227a026
18. TING, S. V., & NEWHALL, W. F. (1965). The occurrence of a natural antioxidant in citrus fruit. *Journal of Food Science*, *30*(1), 57-63. https://doi.org/10.1111/j.1365-2621.1965.tb00263.x
19. (n.d.). ARS Home : USDA ARS. https://www.ars.usda.gov/arsuserfiles/80400525/data/flav/flav_r03-1.pdf
20. Miyake, Y., Yamamoto, K., Morimitsu, Y., & Osawa, T. (1997). Isolation of *c*-glucosylflavone from lemon peel and Antioxidative activity of flavonoid compounds in lemon fruit. *Journal of Agricultural and Food Chemistry*, *45*(12), 4619-4623. https://doi.org/10.1021/jf970498x