Austin Journal of Nutrition & Metabolism

Open Access

Austin Publishing Group

Review Article

Food Benefits and Nutraceutical Properties of the Red Beet

Lydia Ferrara*
Department of Pharmacy, University of Naples Federico II, Via Domenico Montesano 49, 80131 Naples, Italy

***Corresponding author:** Lydia Ferrara, Department of Pharmacy, University of Naples Federico II, Via Domenico Montesano 49, 80131 Naples, Italy

Received: May 22, 2020; **Accepted:** June 17, 2020; **Published:** June 24, 2020

Abstract

Red Beet, Beta vulgaris L., is a plant known since ancient times for its nutritional and therapeutic properties. The development of beet cultivation has been linked to the discovery of the possibility of extracting sugar from its roots. Studies on its analytical composition have highlighted the richness in micro and macromutrients and currently red beet is highly appreciated both in the food and pharmacological fields. It contains many pigments, including betadine and betalains which, in addition to being used as natural dyes in many industrial sectors, are used as supplements for their medicinal properties, without presenting any toxicity or addictive phenomena and being able to be used even for a long time.

Keywords: Red Beet; Nitrates; Pigments; Nutrition; Pharmacological Activity

Introduction

Red Beet is a plant belonging to the Chenopodiacee family, of which many varieties are known: vegetable, fodder, sugar beet, which differ from each other mainly in the shape and color of the root. The currently known species, Beta vulgaris L. was obtained by cultural improvement of the wild variety, Beta maritima, known since ancient times and used in all its parts both as food and for medicinal properties. Originally from northern Africa, wild beet was already known to the Assyrians and Babylonians; in Greece and Aristotle and his disciples describe the different varieties of beet, known at that time by classifying them according to color.

Among the Romans it was used as food and for its medicinal properties, in particular the roots were used mainly for the curative broth, to treat fever and other ailments. Its diffusion in France and in Spain was favored by the cultivation of beetroot in the monasteries, but the greatest consumption in Europe is strictly connected to the possibility of extracting sugar from the roots. In 1747, in fact, the Prussian chemist Andreas Sigismund Marggraf began to produce sugar commercially and opened the first factory in 1801 in Cunern, Poland.

Many varieties of this vegetable are known: table beet, Beta vulgaris red variety, forage beet , Beta vulgaris crassa variety or the red mammouth; garden beet, Beta vulgaris var cruenta; rib beet, Beta vulgaris var cicla, sugar beet, Beta vulgaris var saccarifera. The latter is a Mediterranean plant that has been intensively cultivated in Italy since the end of the eighteenth century, especially in the Po Valley and in the provinces of Ferrara and Rovigo, where most of the sugar beet factories are located.

Table Beet, Beta vulgaris rubra variety (Red Beet) is a biennial herbaceous plant with stems that can reach 1-2 m in height, with heart-shaped leaves 5-20 cm long, green with reddish streaks and globular roots, round or elongated of an intense purple-red color, with a light and sweet taste, which are included in many recipes and are an excellent base for centrifuged. The Red Beet is harvested between August and February and the roots are mainly consumed; the leaves are also used as a food being very rich in vitamins.

Chemical composition

Red Beet is a low-calorie vegetable 19Kcal/100g and has a very complex composition. Its main components are: Water 91% Carbohydrates (sucrose) 4%; Protein 1.10%; Total fiber 2.60%; Minerals: Sodium 84mg; Potassium 300mg; Iron 0.40mg; Calcium 20mg; Phosphorus 21mg; Magnesium 23mg; Zinc 0.4mg; Selenium 0.7mcg; Nitrates 400-600 mg; Folic acid 109 mcg; Biotin 10.5 mcg; Vitamins: C=7mg; B1=0.03 mg; B2=0.02 mg; B3=0,20mg; A=33 IU; Amino acids: aspartic acid, glutamic acid, arginine, alanine, cystine, glycine, phenylalanine, histidin, isoleucine, leucine, lysine, proline, methionine, serine, tyrosine, tryptophan, valine and threonine; Flavonoids: Quercetin, Myricetin, Rutin and kaempferol; a bicyclic alcohol, Geosmin; Pigments.

The purplish red of the Red Beet is a natural dye formed by different pigments belonging to the class of Betalains, substances indole derived, which have as a precursor Betalamic acid and are characteristic of the Caryophyllate plants. To these belong the Betacyanins, red purple pigments, whose main component is Betanin, others are: isobetanin, probetanin and neobetanin; Betaxanthins, yellow-orange pigments which in plants include vulgaxanthin, miraxanthin, portulaxanthin and indicaxanthin; other of Betalains degradation products are light brown .

Betalains are water-soluble pigments found in the vacuoles of plant cells in the form of glucosides. Betalains extracted from beetroot are made up of about 90% of Betacyanine and are used by the food industry as a colorant E162, which being harmless to humans, can be present in various pastry products, in fruit jellies, in gum chew, in sauces and condiments, in packaged ice cream and popsicles [1,2].

Betalamic acid is the chromophore common to all betalainic pigments and the nature of the residue added to it determines

Citation: Ferrara L. Food Benefits and Nutraceutical Properties of the Red Beet. Austin J Nutr Metab. 2020; 7(3): 1084.

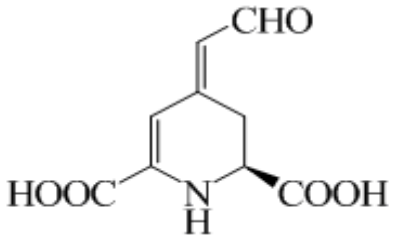
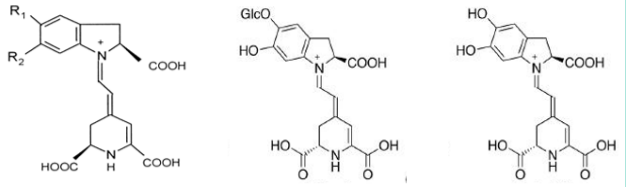


Figure 1: Betalamic Acid.



Betacyanin **Betanin glucoside** **Betanin**

Figure 2:

its classification in Betacyanin or Betaxantin; Betanin glucoside (betanidine-5-O-β-glucoside) is the main component of Betacyanin (Figure 1, Figure 2) [3,4].

Betalains are substances very sensitive to various factors: pH, temperature, light, oxygen, water activity, presence of metal ions, enzymes, which lead to a degradation process of these substances, the most evident manifestation of which is the fading of the color [5-10].

Few studies are present in the literature regarding the change in the properties of Betalains when are added to foods to improve appearance. Following interaction with the food matrix, in fact, pigments can change their color and adversely affect the final appearance of the food: the food matrix can act positively as a color stabilizer, but it can also exert a negative action if the color it is altered following browning caused by enzymatic reactions or other factors. It is very important to know the composition of the food and the stability conditions of the pigments to obtain a satisfactory result. The pH value of four was determined to stabilize the color and allow the use of red beet juice as a natural coloring agent in foods with a low acid content such as meat and dairy products, to extend the storage time [11-14]. The addition of beetroot extracts to mayonnaise also showed a greater inhibitory effect on lipid oxidation than synthetic antioxidants [15,16] Conservation at low temperatures is necessary to maintain the characteristics of the food and its coloring over time.

Instability to heat and neutral pH favors the degradation of Betalains which, forming brown pigments, cannot be used to color cakes or baked goods. Temperature is another factor influencing the decomposition of these substances and it has been noted, for the purpose of food preservation, that it is preferable not only a pasteurization process at low temperatures instead of sterilization, but also storing the products in place fresh to allow color regeneration of betacyanin after thermal exposure [17].

A food attracts the attention of consumers both for its appearance and for its taste. Red Beet is a very pleasant vegetable with a sweetish taste that lends itself well to various preparations: it can be eaten raw; grated and seasoned with only lemon juice; boiled, cooked in the oven, fried in a pan; mixed with other ingredients for the preparation of soups and vegetable soups. Geosmin, a volatile terpenoid substance, commonly produced by many soil microorganisms, is responsible for the earthy, not always welcome, taste of Red Beet. Despite many studies, there is still no certainty on the origin of the presence of this substance: it is not known, in fact, whether Geosmin is a by-product of beet metabolism or rather it is synthesized by the cyanobacteria present in the soil and absorbed by beets during maturation [18-20]. For sensorial delicate foods some methods have been proposed to best remove this odor, such as a membrane process or a simple distillative removal during the concentration of the juice [21-24].

For its complex chemical composition, Red Beet has been attributed dietary and health-giving properties, already known in traditional medicine, which have been supported by modern analytical techniques; in particular, Betalains have shown remarkable antioxidant, anti-inflammatory and anticancer properties.

Pharmacological activity

Red Beet for its composition in mineral salts, vitamins, trace elements can be considered a natural tonic that intervenes favorably against fatigue, lack of appetite and anemia, revitalizing red blood cells and increasing the level of iron in the blood. It is also very rich in nitrates, precursors of nitric oxide, a very important molecule for the health of the cardiovascular system, lowering blood pressure and promoting the flow of blood, oxygen and nutrients to the cells. Nitrates also improve athletic performance, reducing oxygen consumption and preventing the formation of lactic acid. Integration with beetroot juice can improve cardiorespiratory endurance in athletes by increasing muscle efficiency, improving performance at various distances, mitigating the ergolytic effects of hypoxia on cardiorespiratory endurance. Considering these positive effects, beet juice has been proposed as a therapeutic support supplement for patients with chronic obstructive pulmonary disease, hypertension, heart failure [25-29].

Betain known as Trimethylglycine is a natural substance that can be extracted from beetroot which is considered to be a group B vitamin. Betain in nature is ubiquitous: it is found in plants, animals, microorganisms and rich food sources including seafood, spinach and bran of wheat. The main physiological role of Betain is to function as a methyl donor and as an osmolyte, maintaining the cellular and ionic balance of water, protecting against heat stress, preventing dehydration and osmotic inactivation. This compound has the ability to release methyl groups to various substances transforming itself into dimethylglycine. In the body it is capable of methylating homocysteine into methionine, in the presence of vitamin B12 and folic acid and for this activity it is used in the treatment of homocystinuria and hyperhomocysteinemia, the presence of which is associated with a high cardiovascular risk [30]. A high presence of homocysteine, the amino acid sulphide metabolite of methionine, increases the risk of ischemic stroke, thrombo-embolism and senile dementia in addition to arteriosclerosis in the blood [31].

A relationship between the increased presence of homocysteine and the loss of memory of elderly people has been highlighted and also to the onset of Alzheimer's disease, generally observed in the elderly population, due to the very low concentration of homocysteine remethylation cofactors [32]. Betain supplementation together with

vitamin B12 and folic acid can improve methylation and protect the brain from stroke risk and dementia. Betain as a donor of methyl groups participates in a large number of metabolic processes and its deficiency in nutrition can compromise liver function, increasing lipid concentration due to impaired fat metabolism, with consequent hepatic steatosis that often occurs in people with syndrome metabolic, diabetic, which over time, if left untreated, can develop into cirrosi [33]. Betain has shown a significant hepatoprotective effect both in healthy subjects and in subjects with liver pathologies, against damage due to excessive alcohol consumption; also important is the lowering of the concentration of LDL cholesterol and triglycerides, accompanied by an increase in the HDL fraction [34-38].

Red Beet is one of the few foods that contain bioactive pigments, Betalains, which show important antioxidant and anti-inflammatory properties both *in vitro* and *in vivo*, to suggest the use of this food in pathologies promoted by oxidative stress and chronic inflammation such as liver disease , arthritis, arthrosis, tumors, diabetes, obesity [39-41]. Oxidizing molecules are reactive oxygen species and at low concentration are produced by cellular metabolism; they participate in many biological phenomena, such as mutation, carcinogenesis, degenerative diseases, inflammation, aging and development. When their concentration increases due to prolonged exposure of the cells to xenobiotics, UV radiation or an inflammatory process, the normal cellular redox balance is disturbed, causing a condition indicated as oxidative stress in which, due to the lack of antioxidant defenses, occur functional alterations of DNA, proteins, lipids, carbohydrates, which are sensitive to oxidation [42-46].

Betalains and beet extracts also containing flavonoids and nitrates have emerged as powerful anti-inflammatory agents. They have shown to be able to interfere with the factor Nuclear Factor-Kappa B (Nf-kB), which is the main cause of the presence of inflammatory substances such as cytokines, chemokines, apoptotic and phagocytic cells, which occur in chronic diseases. Studies in rats showed that the use of beet extracts was able to attenuate both the response to Nf-kB in a dose-dependent manner and inhibit the action of the cyclooxygenase-2(COX-2) important precursor of prostaglandins. The beet extract, rich in betanidine orally administered as caspules ,in patients suffering from osteoarthritis, alleviated the pain by having decreased several inflammatory cytokines such as Tumor Necrosis Factor-Alpha (TNF-alfa) and interleukin -6 (IL-6) [47,48]. Lipoxygenase (LOX), a catalytic enzyme essential for the synthesis of leukotrienes, was also inhibited in a dose dependent manner, due to the presence of betanidine. Intraperitoneal treatment reduced carrageenan-induced rat paw edema and neutrophil migration into skin tissue. The effectiveness of Red Beet extracts to fight inflammation provides a response comparable to that of anti-inflammatory drugs commonly used in medicine, increasing the possibility that Red Beet supplements rich in Betanin and Betalains may be a valid alternative to synthetic drugs. , being free of undesirable side effects.

Conclusion

Red Beet represents an important and economic source of nutrients and functional products. To the beet are attributed many properties for dietary and healthy in addition to being rich in sugars, mineral salts and vitamins and other useful substances : it absorbs toxins from the cell and facilitates its elimination, it is purifying, mineralizing, restorative, promotes digestion, treats anemias, pathologies of the brain system, stimulates the production of red blood cells. The nitrates contained in beet juice protect the cardiovascular system by controlling hypertension and preventing heart disease. Modern pharmacology has highlighted the energizing, restorative, hypoglycemic, antioxidant and anti-inflammatory properties of its constituents. The secondary metabolites, Betalains, used in the food industry as dyes show antitumor activity and play an important role as antioxidants and anti-inflammatories.

References

1. Esatbeyoglu T, Wagner AE, Schini-Kerth VB, Rimbach G. Betanin-a food colorant with biological activity. Mol Nutr Food Res. 2015; 9: 36-47.
2. Chhikara N, Kushwaha K, Sharma P, Gat Y, Panghal A. Bioactive compounds of beetroot and utilization in food processing industry: A critical review. Food Chem. 2019; 272: 192-200.
3. Stintzing FC, Carle R. Functional properties of anthocyanins and betalains in plants, food, and in human nutrition. Trends Food Sci Technol. 2004; 15: 19-38.
4. Stintzing FC, Carle R. Betalains-Emerging prospects for food scientists. Trends in Food Sci Technol. 2007; 18: 514-525.
5. Delgado-Vargas F, Jiménez AR, Parades-López O. Natural pigments: carotenoids, anthocyanins, and betalains - characteristics, biosynthesis, processing, and stability. Crit Rev Food Sci Nutr. 2000; 40: 173-289.
6. Herbach KM, Stintzing FC, Carle R. Betalain stability and degradation: structural and chromatic aspects J Food Sci. 2006b; 71: R41-R45.
7. Herbach KM, Stintzing FC, Carle R. Impact of thermal treatment on color and pigment pattern of red beet (Beta vulgaris L.) preparations. J Food Sci. 2004; 69: C491-C498.
8. Attoe EL, von Elbe JH. Degradation kinetics of Betanine in solution as influenced by oxigen. J Agric Food Chem. 1982; 30: 708-712.
9. Czapski J. The effect of heating conditions on losses and regeneration of betacyanins. Z Lebensm Unters Forch. 1985; 180: 21-25.
10. Pasch JH, von Elbe JH. Betanine stability inbuffered solutions containing organic acids, metal, cations, antioxdants, or sequestrants. J Food Sci. 1979; 44: 72-76.
11. von Elbe JH, Maing IY, Amundson CH. Colour stability of betanin. J Food Sci. 1974; 39: 334-333.
12. Pasch JH, von Elbe JH, Sell RJ. Betalains as colorants in dairy products. J Milk Food Technol. 1975; 38: 25-28.
13. Jin SK, Choi JS, Moon SS, Jeong JY, Kim GD. The Assessment of Red Beet as a Natural Colorant, and Evaluation of Quality Properties of Emulsified Pork Sausage Containing Red Beet Powder during Cold Storage. Korean J Food Sci Anim Resour. 2014; 34: 472-481.
14. Lashley D, Wiley RC. A betacyanine decolorizing enzyme found in red beet tissue. Food Sci. 1979; 44: 1568- 1569.
15. Raikos V, McDonagh A, Ranawana V, Duthie G. Processed beetroot (Beta vulgaris L.) as a natural antioxidant in mayonnaise: Effects on physical stability, texture and sensory attributes. Food Sci Hum Wellness. 2016; 5: 191-198.
16. Kaimainen M, Laaksonen O, Järvenpää E, Sandell M, Huopalahti R. Consumer acceptance and stability of spray dried betanin in model juices. Food Chem. 2015; 187: 398-406.
17. Han D, Kim SJ, Kim SH, Kim DM. Repeated regeneration of degraded red beet juice pigments in the presence of antioxidants. J Food Sci. 1998; 63: 69-72.
18. Jiang J, Cane DE. Geosmin biosynthesis. Mechanism of the fragmentation-rearrangement in the conversion of germacradienol to geosmin. J Am Chem Soc. 2008; 130: 428-429.

19. Lu G, Edwards CG, Fellman JK, Mattinson DS, Navazio J. Biosynthetic origin of geosmin in red beets (beta vugaris L). J Agric Food Chem. 2003; 51: 1026-1029.

20. Lu G, Edwards CG, Fellman JK, Mattinson DS, Navazio J. Quantitative determination of Geosmin in red beets (Beta vulgaris L) using headspace solid-phase microextraction. J Agric Food Chem. 2003; 51: 1021-1025.

21. Murray KE, Bannister PA, Buttery RG. Geosmin: an important volatie constituent of Beetroot (Beta vulgaris) Chem Ind. 1975; 973-974.

22. Pasch JH, e von Elbe JH. Sensory evaluation of betanine and concentrated beet juice. J Food Sci. 1978; 43: 1624-1625.

23. Lee YN, Wiley RC, Shen MJ. Schlimme DV. Purification and concentration of betalaines by ultrafiltration and reverse osmosis J Food Sci. 1982; 47: 465-471.

24. Philip T. Purification and concentration of natural colorant by membranes. Food Technol. 1984; 38: 107-108.

25. Vanhatalo A, Fulford J, Bailey SJ, Blackwell JR, Winyard PG, Jones AM. Dietary nitrate reduces muscle metabolic perturbation and improves exercise tolerance in hypoxia. J Physiol. 2011; 589: 5517-5528.

26. Lundberg JO, Govoni M. Inorganic nitrate is a possible source for systemic generation of nitric oxide. Free Radic Biol Med. 2004; 37: 395-400.

27. Kapil V, Khambata RS, Robertson A, Caulfield MJ, Ahluwalia A. Dietary nitrate provides sustained blood pressure lowering in hypertensive patients: A randomized, phase 2, double-blind, placebo-controlled study. Hypertension. 2015; 65: 320-327.

28. Domínguez R, Cuenca E, Maté-Muñoz JL, García-Fernández P, Serra-Paya N. Effects of Beetroot Juice Supplementation on Cardiorespiratory Endurance in Athletes. A Systematic Review. Nutrients. 2017; 9: 43.

29. Clifford T, Howatson G, West DJ, Stevenson EJ. The potential benefits of red beetroot supplementation in health and disease. Nutrients. 2015; 7: 2801-2822.

30. Kempson SA, Vovor-Dassu K, Day C. Betaine transport in kidney and liver: use of betaine in liver injury. Cell Physiol Biochem. 2013; 32: 32-40.

31. Lawson-Yuen A, Levy HL. The use of betaine in the treatment of elevated homocysteine. Mol Genet Metab. 2006; 88: 201-207.

32. Kempson SA, Zhou Y, Danbolt NC. The betaine/GABA transporter and betaine: roles in brain, kidney, and liver. Front Physiol. 2014; 5: 159-175.

33. Day CR, Kempson SA. Betaine chemistry, roles, and potential use in liver disease. Biochim Biophys Acta. 2016; 1860: 1098-1106.

34. Kharbanda KK. Methionine metabolic pathway in alcoholic liver injury. Curr Opin Clin Nutr Metab Care. 2013; 16: 89-95.

35. Medici V, Peerson JM, Stabler SP, French SW, Gregory JF, Virata MC, et al. Impaired homocysteine transsulfuration is an indicator of alcoholic liver disease. J Hepatol. 2010; 53: 551-557.

36. Halsted CH. B-Vitamin dependent methionine metabolism and alcoholic liver disease. Clin Chem Lab Med. 2013; 51: 457-465.

37. Mato JM, Martínez-Chantar ML, Lu SC. Methionine metabolism and liver disease. Annu Rev Nutr. 2008; 28: 273-293.

38. Tan D, Wang Y, Bai B, Yang X, Han J. Betanin attenuates oxidative stress and inflammatory reaction in kidney of paraquat-treated rat. Food Chem Toxicol. 2015; 78: 141-146.

39. Wiley RC, Lee YN. Recovery of betalains from red beet by diffusion-extraction procedure J Food Sci. 1978; 43; 1056-1058.

40. Pietrzkowski Z, Nemzer B, Spórna A, Stalica P, Tresher W, Keller R, et al. Influence of betalin-rich extracts on reduction of discomfort associated with osteoarthritis. New Med. 2010; 1: 12-17.

41. Lechner JF, Stoner GD. Red beetroot and betalains as cancer chemopreventative agents. Molecules (Basel, Switzerland). 2019; 24: 1602-1614.

42. El Gamal AA, AlSaid MS, Raish M, Al-Sohaibani M, Al-Massarani SM, et al. Beetroot (Beta vulgaris L.) extract ameliorates Gentamicin-induced nephrotoxicity associated oxidative Stress, Inflammation, and apoptosis in rodent model. Mediators Inflamm. 2014; 2014: Article ID-983952; pp-12.

43. Vulić JJ, Ćebović TN, Čanadanović-Brunet JM, Ćetković GS, Čanadanović VM, et al. *In vivo* and *in vitro* antioxidant effects of beetroot pomace extracts. J Funct Foods. 2014; 6: 168-175.

44. Lu X, Wang Y, Zhang Z. Radioprotective activity of betalains from red beets in mice exposed to gamma irradiation. Eur J Pharmacol. 2009; 615: 223-227.

45. Tesoriere L, Butera D, D'Arpa D, Di Gaudio F, Allegra FD, Gentile C, et al. Increased resistance to oxidation of betalain-enriched human low density lipoproteins. Free Radic Res. 2003; 37: 689-696.

46. Escribano J, Pedreno MA, Garcia-Carmona F, Munoz R. Characterization of the antiradical activity of betalains from Beta vulgaris L. roots. Phytochem Anal. 1998; 9: 124-127.

47. Martinez RM, Longhi-Balbinot DT, Zarpelon AC, Staurengo-Ferrari L, et al. Anti-inflammatory activity of Betalain-rich dye of Beta vulgaris: effect on edema, leukocyte recruitment, superoxide anion and cytokine production. Arch Pharm Res. 2015; 38: 494-504.

48. Kapadia GJ, Rao GS, Ramachandran C, Lida A, Suzuki N, Tokuda H, et al. Synergistic cytotoxicity of red beetroot (Beta vulgaris L.) extract with doxorubicin in human pancreatic, breast and prostate cancer cell lines. J Complement Med. 2013; 10: 113-122.