

## Review

Nutritional and functional potential of *Beta vulgaris cicla* and *rubra*

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## ARTICLE INFO

## Article history:

Received 10 April 2013

Accepted in revised form 28 May 2013

Available online 7 June 2013

## Keywords:

*Beta vulgaris cicla**Beta vulgaris rubra*

Chenopodiaceae

Antitumoral activity

Antioxidant capacity

Functional foods

## ABSTRACT

Swiss chard (*Beta vulgaris cicla*, BVC) and beetroot (*Beta vulgaris rubra*, BVR) are vegetables of the *Chenopodiaceae* family, widely consumed in traditional western cooking. These vegetables represent a highly renewable and cheap source of nutrients. They can be cultivated in soils with scarce organic material and little light and water. BVC and BVR have a long history of use in folk medicine. Modern pharmacology shows that BVC extracts possess antihypertensive and hypoglycaemic activity as well as excellent antioxidant activity. BVC contains apigenin flavonoids, namely vitexin, vitexin-2-O-rhamnoside and vitexin-2-O-xyloside, which show antiproliferative activity on cancer cell lines. BVR contains secondary metabolites, called betalains, which are used as natural dyes in food industry and show anticancer activity. In this light, BVC and BVR can be considered functional foods. Moreover, the promising results of their phytochemicals in health protection suggest the opportunity to take advantage of the large availability of this crop for purification of chemopreventive molecules to be used in functional foods and nutraceutical products.

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**Abbreviations:** ABTS, 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulphonic acid); APAF-1, Apoptotic Protease Activating Factor-1; Apo1, Apoptosis Antigen 1; BAX, Bcl2-Associated X protein; Bcl2, B-cell lymphoma 2; BSA, Bovine Serum Albumin; BVC, *Beta vulgaris cicla*; BVR, *Beta vulgaris rubra*; CAA, Cellular Antioxidant Activity; Caspase, Cysteine-Aspartic Proteases; CdK, Cyclin-dependent Kinase; COX, Cyclooxygenase; DCFH-DA, Dichlorofluorescein-Diacetate; DNA, Deoxyribonucleic Acid; DPPH, 2,2-diphenyl-1-picrylhydrazyl; ELISA, Enzyme Linked Immunosorbent Assay; GC-MS, Gas chromatography-mass spectrometry; GLUT2, Glucose Transporter 2; HLE, Hawthorn Leaf Extract; HPLC-MS, High Performance Liquid Chromatography–Mass Spectrometry; IC<sub>50</sub>, Half maximal Inhibitory Concentration; LDL, Low Density Lipoprotein; MM2, Paraneoplastic Ma antigen 2; MRP-2, Multidrug Resistance-associated Protein-2; NO, Nitric Oxide; NOS, Nitric Oxide Synthase; ORAC, Oxygen Radical Absorbance Capacity; PAI1, Plasminogen Activator Inhibitor-1; PARP, Poly-ADP Ribose Polymerase; P-gp, P-glycoprotein; PPARγ, Peroxisome Proliferator-Activated Receptor gamma; RBC, Red Blood Cell; ROS, Reactive Oxygen Species; TBARS, Thiobarbituric Acid Reactive Substances; VOR, Vitexin-2-O-rhamnoside; VOX, Vitexin-2-O-xyloside; WAF, Cyclic-Dependent Kinase-interacting protein 1

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## 1. Introduction

Red beetroot (*Beta vulgaris rubra*, BVr) and Swiss chard (*Beta vulgaris cicla*, BVc) are members of the *Chenopodiaceae*. This family contains important food crops, such as *Spinacia oleracea* (spinach), which is the most consumed *Chenopodiaceae* leafy vegetable in Europe [[www.fao.org/economic/ess/en/](http://www.fao.org/economic/ess/en/)], *Salsola kali*, or prickly saltwort, currently used in western countries, and *Chenopodium quinoa*, commonly known as quinoa [1].

In the *Chenopodiaceae* family, there are also two wild edible representatives: *Chenopodium album*, known as lambsquarter and in indi as *bathua* [2], and *Chenopodium bonus henricus* [3], also called “mountain spinach”, as it grows in the grazing lands of the Alps [4].

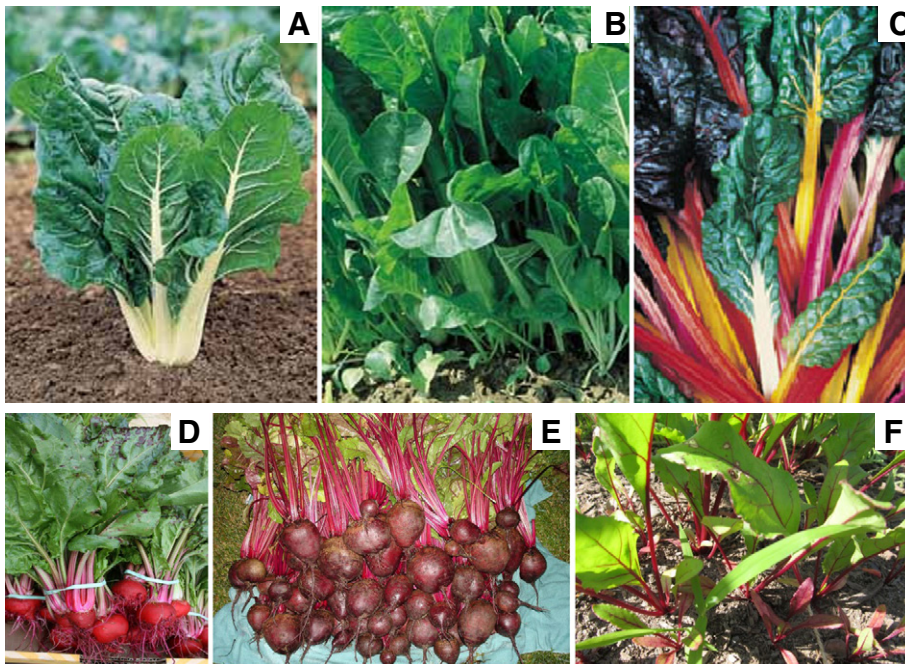
BVc and BVr have been used for food since 1000 B.C. by all populations of the Mediterranean basin. The Romans utilized the BVc and BVr leaves for food, while the roots were used for medicinal applications. BVc became commercially important in 19th century in Europe, following the development of the sugar beet (*Beta vulgaris saccharifera*) in Germany [4].

In Italy, the two most produced BVc cultivars are *Bieta a costa Bianca*, for home use, and *Bieta erbetta da taglio* for industry use (Fig. 1), whereas there are several varieties of BVr, such as the *Chioggia*, *Detroit* and *Ruby Queen* (Fig. 1).

This review focuses on botany, chemical composition, biological activity and nutritional value of BVc and BVr as well as on the biological and pharmacological activities of their phytochemicals.

## 2. Taxonomy

Beet is classified taxonomically as *Dicotyledonae*, *Caryophyllidae*, *Chenopodiaceae* and *Beta* [5]. On the basis of morphological characters, the genus *Beta* was sub-divided into two groups: cultivated and wild maritime beets. In the latter group, the sea beets (*Beta vulgaris maritima*) is the unique species, which represents the ancestral form of all the species. In the cultivated group, there are sugar beets (*Beta vulgaris saccharifera*), fodder beets (*Beta vulgaris crassa*), leaf beets (*Beta vulgaris cicla*) and garden beets (*Beta vulgaris rubra*) [6].



**Fig. 1.** Pictures of the main cultivars of *Beta vulgaris cicla* and *rubra*. A) Swiss chard, *bieta costa bianca*; B) Swiss chard, *bieta erbetta da taglio*; C) Swiss chard, Hybrid F1; D) Red Beetroot cv *Chioggia*; E) Red Beetroot cv. *Detroit*; F) Red Beetroot cv *Ruby Queen*.

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