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Broccoli (*Brassica Oleracea var. Italica*): Potential candidate in the health management

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ABSTRACT

Broccoli (Brassica oleracea var. italica), commonly the aim of this study is to overview its therapeutic effects than its nutritive and industrial effects. This review article was carried out by searching studies in PubMed, Medline, , Web of Science, and Iran Medex databases up to 2016.totally, of 90 found articles,40 articles(42 in vitro and 5 animal studies) were included. The search terms were "Brassica oleracea var. italica,"Broccoli", "therapeutic", "pharmacological", Various studies have shown that Broccolipossess Antiamnesic Effect, Antioxidant Effect, Antioxidant and antiproliferative activities, Neuroprotective Effect, Renal damage Effect, Anti-Diabetic and Anti-Inflammatory Effects, Dyslipidemia and hepatic injury Effect, Antioxidant and anti-inflammatory potential Effect, Apoptotic role Effect, Antioxidant and in vitro anticancer effect ,Anticancer activity, Antigenotoxic Effect, Antiproliferative effects. Broccoliis widely used for therapeutic and purposes that trigger its significant value. Various combinations and numerous medicinal properties of its extract, essential oils, its stems and leaves demand further and more studies about the other useful and unknown properties of this multipurpose plant.

Keywords: Brassica oleracea var. italica, Broccoli, therapeutic, pharmacological

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INTRODUCTION

It is proved that herbal medicine is effective in the treatment of many diseases [1-10].

Broccoli is an edible green plant in the cabbage family whose large flowering head is eaten as a vegetable. The word broccoli comes from the Italian plural of broccolo, which means "the flowering crest of a cabbage", and is the diminutive form of brocco, meaning "small nail" or "sprout"[11, 12]. Broccoli is often boiled or steamed but may be eaten raw. Broccoli is classified in the Italica cultivar group of the species Brassica oleracea. Broccoli has large flower heads, usually green in color, arranged in a tree-like structure branching out from a thick, edible stalk. The mass of flower heads is surrounded by leaves. Broccoli resembles cauliflower, which is a different cultivar group of the same species[13-15].

Broccoli is a result of careful breeding of cultivated leafy cola crops in the northern Mediterranean starting in about the 6th century BC. Since the time of the Roman Empire, broccoli has been considered a uniquely valuable food among Italians. Broccoli was brought to England from Antwerp in the mid-18th century by Peter Scheemakers. Broccoli was first introduced to the United States by Southern Italian immigrants, but did not become widely known until the 1920s.

There are three commonly grown types of broccoli. The most familiar is Calabrese broccoli, often referred to simply as "broccoli", named after Calabria in Italy. It has large [10 to 20 cm] green heads and thick stalks. It is a cool season annual crop. Sprouting broccoli has a larger number of heads with many thin stalks[16-18]. Purple cauliflower is a type of broccoli sold in southern Italy, Spain, and the United Kingdom. It has a head shaped like cauliflower, but consisting of tiny flower buds. It sometimes, but not always, has a purple cast to the tips of the flower buds[19, 20].

Antiamnesic Effect

To examine the antiamnesic effects of broccoli [Brassica oleracea var. italica] leaves, we performed in vitro and in vivo tests on amyloid beta [Aβ]-induced neurotoxicity. The chloroform fraction from broccoli leaves [CBL] showed a remarkable neuronal cell-protective effect and an inhibition against acetylcholinesterase [AChE]. The ameliorating effect of CBL on Aβ1-42-induced learning and memory impairment was evaluated by Y-maze, passive avoidance, and Morris water maze tests. The results indicated improving cognitive function in the CBL group. After the behavioral tests, antioxidant effects were detected by superoxide dismutase [SOD], oxidized glutathione [GSH]/total GSH, and malondialdehyde [MDA] assays, and inhibition against AChE was also presented in the brain. Finally, oxo-dihydroxy-octadecenoic acid [oxo-DHODE] and trihydroxy-octadecenoic acid [THODE] as main compounds were identified by quadruple time-of-flight ultra-performance liquid chromatography [Q-TOF UPLC-MS] analysis. Therefore, our studies suggest that CBL could be used as a natural resource for ameliorating Aβ1-42-induced learning and memory impairment [21].

Antioxidant effect

The antioxidant potential of the extracts of bioactive compounds from Brassica oleracea varcapitatawas evaluated. The extracts of all runs presented antioxidant activities towards the three radicals, but the highest activities for all radicals were using the extracts obtained in the run 2. The use of supercritical CO2 extraction to obtain bioactive compounds of *B. oleracea varcapitata* showed to be a promising alternative to conventional extraction methods, since allowed the extraction of compounds with scientific and industrial interest [22].

Antioxidant activity of Samples prepared from fresh broccoli (Brassica oleracea L.) sprouts by water distillation or freeze-drying were examined. All samples exhibited dose-dependent antioxidant activity. Both dichloromethane extract samples from a water distillate of broccoli sprouts and freeze-dried broccoli sprouts showed potent antioxidant activity, which was comparable to that of BHT. These isothiocyanates are known to possess antioxidant properties. Possible phenolic antioxidants found are 4-(1-methylpropyl) phenol (0.012 μg/g), 4-methylphenol (0.159 μg/g), and 2-methoxy-4-vinylphenol (0.009 μg/g). The present study demonstrates that broccoli sprouts are a good source of natural antioxidants [23].

The relationship among different electron transfer (ET) methods for measuring AA and QTLs of AA measured with ET assays and for phenolic, carotenoid and anthocyanin contents in leaves and flower buds in a DH population of B. oleracea was studied. AA of the mapping population is related to phenolic compounds but also to carotenoid content. Three genomic regions determined variation for more than one ET method measuring AA. Result showed that several candidate genes related to phenylpropanoid biosynthesis are proposed for the QTLs found [24].

The antioxidant activity of sprouts from four Brassica oleracea varieties was evaluated .Light cycles and sprouting influenced the potential antioxidant activity of sprouts and significant differences were observed between varieties. Generally, antioxidant activity decreased with sprouting and increased in the presence of light, whose discriminant effect was highly significant ($P<0.001$). Red cabbage sprouts produced under light cycles showed the highest antioxidant activity [25].

An efficient ultrasonic-assisted enzymatic extraction technique was applied to extracting phenolics from broccoli inflorescences without organic solvents. The synergistic model of enzymolysis and ultrasonication simultaneously was selected, and the enzyme combination was optimized by orthogonal test: cellulase 7.5 mg/g FW , pectinase 10 mg/g FW, and papain 1.0 mg/g FW. The operating parameters in ultrasonic-assisted enzymatic extraction were optimized with response surface methodology using Box-Behnken design [26].

The expression analysis of antioxidant defense genes in *Brassica oleracea* and in Trifoliumrepens was examined. It appeared that strongest gene expression variations in T. repens were observed when plants are exposed to Cd

(metallothionein and ascorbate peroxidase upregulations) whereas strongest variations in B. oleracea were observed in case of Cd/Pb co-exposures (metallothionein, glutathione transferase, and peroxidase upregulations). Results also suggest that there is a benefit to use complementary species in order to better apprehend the biological effects in ecotoxicology [27].

the effects of supplementary UV radiation during the vegetative period on antioxidant compounds, antioxidantactivity and postharvest quality of broccoli heads during long term storage was studied. Total soluble solids, solids content and titratable acidity decreased continuously during storage. Titratable acidity was not affected by UV radiation doses during the storage time whereas soluble solids and solids content (dry matter) were significantly affected by UV doses. Pre-harvest UV radiation during vegetative period seems to be a promising tool for increasing the beneficial health components of broccolis [28].

The complex interactions between CO2 increase and salinity were investigated . Nutrients (minerals, soluble protein and total amino acids) and natural antioxidants (glucosinolates, phenolic acids, flavonoids and vitamin C) were determined.result found that for different modes of N fertilisation, the interaction with climatic factors must be considered in the search for an optimal balance between yield and nutritional quality [29].

Antiproliferative activities

Three different broccoli maturity stages subjected to biofortification with selenium were evaluated for antioxidant and antiproliferative activities. Antioxidant trials have shown that the maturation stages biofortified with selenium had significantly higher amounts of phenolic compounds and antioxidant activity, especially seedlings[30].

Neuroprotective Effect

The protective effect on SH-SY5Y cells treated with the fragment Aβ 25-35 was analyzed by two crude juices of broccoli sprouts containing different amounts of phenolic compounds as a result of different growth conditions. Although the effects of the two juices were similar, the juice enriched in phenolic compounds showed a greater efficacy in inducing the activation of the Nrf2 signalling pathway [31].

Renal damage

The impact of Brassica oleracea sprouts juice toward renal damage in Japanese diet-fed SHRSP was evaluated. B. oleracea administration prevented renal damage in salt-loaded SHRSP, independently from SBP, with parallel stimulation of AMPK/SIRT1/PGC1α/PPARα/UCP2 axis. Stimulation of the latter mechanism may provide relevant renal protective effect and play a therapeutic role in target organ damage progression in hypertension [32].

Anti-Inflammatory Effects

The anti-diabetic, anti-inflammatory, antioxidant potential, and total phenolic content (TPC) of green and red kohlrabi cultivars was evaluated. Between the two kohlrabi cultivars, red kohlrabi (RK) had two times more TPC than green kohlrabi (GK) and showed significant antioxidant effects in DPPH, ABTS, and ONOO(-) scavenging assays. The RK MeOH extract exhibited significantly stronger anti-inflammatory, anti-diabetic, and antioxidant effects than that of GK MeOH extract. Result showed that RK extract with a higher TPC might be useful as a potent anti-diabetic, antioxidant, and anti-inflammatory agent [33]. antioxidant and anti-inflammatory activity of cabbage phytochemicals was investigated . The results suggest that these varieties of cabbage heads could contribute as sources of important antioxidant and anti-inflammatory related to the prevention of chronic diseases associated to oxidative stress, such as in cancer and coronary artery disease [35].

Dyslipidemia and hepatic injury

Histopathological and biochemical parameters of red cabbage in rats administered with a cholesterol-rich diet (CRD) was examined. Result found that the potential therapeutic effects of red cabbage in dyslipidemia as well as hepatic injury, that is at least, partly mediated by its antioxidant properties [34].

Apoptotic activity

The rehabilitating role in alleviating the oxidative damage caused by benzo(a)pyrene [B(a)P] was determined. Apoptosis was induced by increasing the release of Cyt c ($p < 0.001$) from mitochondria, decreasing and increasing

the expression of Bcl-2 (p□<□0.01) and Bax (p□<□0.001), respectively. Caspase-3 activity was also enhanced (p□<□0.001) which leads to DNA fragmentation in SFN treated groups[36].

Antioxidant and in vitro anticancer effect

If the 2-pyrrolidinone rich fraction of Brassica oleracea var. capitata exhibiting antioxidant and in vitro anticancer activities was analyzed. The results suggest that the 2-pyrrolidinone have potential anticancer effects, which will lead to the development of new anticancer agents for arresting cancer cells growth in vitro(37). antiproliferative activity of various fractions of red cabbage (Brassica oleraceaevarrubra) was evaluated .This study indicates that purified SFN possesses antiproliferative effects the same as Std SFN and its apoptotic mechanism in HEp-2 cells could be mediated through p53 induction, bax and bcl-2 signaling pathways(38).

Antigenotoxic

The in vivo genotoxic and/or antigenotoxic potential of a Brassica oleraceae hydroalcoholic extract obtained from the leaves, in different cells of mice was evaluated. Result showed no genotoxic or clastogenic effects in different cells of mice. However, it did show a significant decrease in DNA damage induced by doxorubicin. It is suggested that the antigenotoxic properties of this extract may be of great pharmacological importance, and may be beneficial for cancer prevention [39].

A green cultivar and a red cultivar of curly kale were evaluated .The extracts of both green and red curly kale inhibited the cell proliferation of three human colon cancer cell lines (Caco-2, HT-29, and HCT 116). However, extracts from fresh plant material had a significantly stronger antiproliferative effect than extracts from processed plant material [40].

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