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REVIEW ARTICLE

Turnip (*Brassica Rapus* L.): a natural health tonic

Nabo (*Brassica Rapus* L.): um tônico natural para a saúde

Ahsan Javed[1*], Awais Ahmad[1], Muhammad Nouman[1], Adeela Hameed[1], Ali Tahir[1], Umair Shabbir[1]

[1]Government College University, Institute of Home & Food Sciences, Faisalabad - Pakistan

***Corresponding Author:** Ahsan Javed, Government College University, Institute of Home & Food Sciences, Liaqat Block, New Campus of Government College University, Jhang Road, 38040, Faisalabad - Pakistan, e-mail: ahsanjivi08@gmail.com

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Abstract

In addition to basic nutrition, plant-based foods provide substantial amounts of bioactive compounds which deliver desirable health benefits. During the last decade, secondary metabolites, also known as phytochemicals, obtained from plants, have aroused special attention by researchers. Amongst such plants, the turnip contains a few valuable components which not only endorse health benefits but also provide healing properties. Various bioactive components, for example peroxidase, kaempferol, phenolic compounds, sulforaphane, organic acids, vitamin K, glucosinolates etc are highlighted in this manuscript. Likewise, numerous minerals, such as copper, manganese and calcium, and organic acids, such as sinapic and ferulic acids and their derivatives, found in different amounts in fresh greens and turnip roots, are also discussed briefly. The current paper is focused on the phenolic compounds, which act as beneficial compounds for human health and can be isolated from plant foods, especially turnip. Due to the presence of bioactive constituents, turnip imparts a positive role with respect to the hepatic injury caused by diabetes, high antioxidant activity and a good hepatoprotective role. The impact of environmental conditions and processing mechanisms on the phenolic compound composition of Brassica vegetables, with special reference to turnip, was also briefly discussed.

Keywords: Turnip; Phytochemicals; Antioxidant; Vegetable; Health promoting; Therapy.

Resumo

Além de nutrição básica, os alimentos baseados em plantas fornecem quantias substanciais de compostos bioativos que fornecem benefícios de saúde desejáveis. Durante a última década, metabólitos secundários, também conhecidos como fitoquímicos, obtidos de plantas, têm chamado muito a atenção dos pesquisadores. Entre estas plantas, o nabo contém alguns componentes valiosos que não apenas endossam os benefícios à saúde, mas também fornecem propriedades de cura. Uma variedade de componentes bioativos − por exemplo, peroxidase, kaempferol, compostos fenólicos, sulforafano, ácidos orgânicos, vitamina K, glicosinolatos etc. − são ressaltados neste manuscrito. Da mesma forma, numerosos minerais, como cobre, manganês e cálcio, e ácidos orgânicos, tais como os ácidos sinápico e ferúlico e seus derivados, presentes em quantias diferentes em folhas verdes frescas e raízes de nabo, são também discutidos brevemente. Este artigo foca nos compostos fenólicos, que agem como compostos benéficos à saúde humana e podem ser isolados de plantas comestíveis, especialmente de nabo. Devido à presença de constituintes bioativos, o nabo tem um papel positivo com respeito às injurias hepáticas causadas por diabetes, alta atividade antioxidante e um bom papel como protetor hepático. Os impactos das condições ambientais e dos mecanismos de processamento na composição dos compostos fenólicos de legumes Brassica, com referência especial ao nabo, foram também brevemente discutidos.

Palavras-chave: Nabo; Fitoquímicos; Antioxidante; Legumes; Promotor de saúde; Terapia.

1 Introduction

In the present millennium, plant-based functional foods have received substantial attention due to their potential nutritional profile, presumed safety and therapeutic effects. Due to these functional foods, plants provide numerous opportunities for cancer therapy. A wide range of horticultural crops are included in the Brassicaceae family, and some are extensively used in the diet due to their economic significance throughout the world. Various common vegetables are included in the genus Brassica, such as *Bassical Rapa L.* (turnip) also known as Shaljam in Pakistan (Mourato et al., 2015). Since prehistoric times, the turnip has been used for human consumption and is the oldest cultivated vegetable (Kaveh & Chayjan, 2017). This specie is particularly famous in Europe and grows in temperate climates.

Across Eastern America, Asia and European regions, the turnip is considered as a famous nutritious root vegetable, and in ancient Roman and Greek times, it was cultivated as a staple food (Lo Scalzo et al., 2008). Baby turnips, also known as young turnips, are eaten raw in salads. Mature turnips have a stronger taste and their texture becomes firmer and woody as compared to baby turnips, which have a sweeter taste and delicate texture.

There are various varieties of turnips, of which Bavarian turnips are considered the best variety in terms of yield. The leaves of a few *B. rapa* (Bavarian turnip) varieties are also used, and are known as Chinese cabbage. Both the roots and leaves have a pungent flavour and the edible portions of the turnip are used as an ingredient in stews and soups. Similarly, turnip tops and turnip greens have been used as vegetable products in some parts of the globe. A bitter taste, particular sulphurous aroma and pungent flavour are the characteristics of turnips. Likewise, numerous secondary metabolites such as phenolic acid in turnip tops and glucosinolates in turnip greens have been significantly correlating with the flavour and texture. The amount and pattern of the glucosinolates and volatiles in Brassica plants vary according to the plant species, cultivar and vegetable part, as well as to the developmental stage of the plant (Kessler & Baldwin, 2002). When the glucosinolates come into contact with myrosinases in the presence of water (during processing, cutting, tissue chewing or when injured), they give rise to breakdown products (isothiocyanates, thiocyanates, nitriles, epithionitriles and oxazolidines). Both glucosinolates and its derivatives are known to have a wide range of important biological activities (Padilla et al., 2007). Some have been shown to be beneficial (such as the chemoprotective effect against certain cancers in humans), while others are detrimental for human and animal consumption (potentially goitrogenic) (Padilla et al., 2007; Taveira et al., 2009). The persistent bitter taste and aftertaste of turnips are due to the progoitrin and gluconapin present in both turnip greens and tops (Francisco et al., 2011a).

2 Morphological attributes

Turnip grow well in territories in cold environments and may be stored for months after harvest. The leaves are usually light green, thin and sparsely downy. The turnip plant has a white-fleshed edible part, and the large sphered root develops underneath the flowering stems and leaf petioles. The flowers form a bunch at the top of the raceme and are usually raised above the terminal buds. Bolting of turnip plants occurs in late winter, followed by the formation of flower buds, which are also consumed before opening, while still green.

Turnip greens have an intense aroma, the colour of the leaves and a salty taste, while the tops are unique for their colour, moistness, fibrosity in the mouth and bitter taste (Lim, 2015). Two turnip varieties are grown, small, tender ones and large sized ones, the small ones being grown for human consumption and the larger ones for the purpose of livestock feed.

3 Nutritional profile

The nutritional assessment of turnips shows various valuable moieties. 100 grams of turnip roots provides 2-grams dietary fibre, 0.1 gram fat, 6.7 grams carbohydrate, 0.6 gram protein, 1.1 milligrams riboflavin, 0.4 milligram thiamine, 0.08 milligram Vit. $B_{6,}$ 16 milligrams Vit. C, 20 micrograms folate, 50 milligrams calcium, phosphorous and iron, 8 milligrams magnesium, 280 milligrams potassium and 18 milligrams sodium (Lo Scalzo et al., 2008). Thus, turnip root is low calorie (28 calories/100 gram) although it is a good storehouse of minerals, vitamins, dietary fibre and antioxidants.

Many essential nutrients are present in the turnip greens which are not present in the turnip roots. Turnip greens are not only abundant in antioxidants such as carotenoids, xanthins, lutein, vitamin A and vitamin C, but are also an excellent source of vitamin K. Cartea et al. (2010) reported that the vitamin B complex i.e. riboflavin; pantothenic acid and thiamine are abundantly present in the top greens of the turnip. Likewise, calcium, iron, copper and manganese are important mineral sources present in the fresh turnip greens.

4 Phenolic compounds & organic acids

The literature suggests that a diet rich in fruits and vegetables can lessen the appearance of various ailments such as diabetes, cancer, CVD and other diseases (Christensen, 2009). Compounds associated with the health endorsing effects of vegetables are the organosulphur compounds, glucosinolates and other secondary metabolites i.e. carotenoids, phytosterols, (Ferreres et al., 2005). Witman (2011) reported that the focus has recently been diverted towards other potential health endorsing compounds found in different natural vegetable products, partly explaining the health effects of, as an example, carrots and other related vegetables, which contain polyacetylenes of the falcarinol-type, which show numerous biological activities including anti-inflammatory and anti-cancer effects.

A diet containing vegetables is the chief source of the flavonoid compounds (Haytowitz et al., 2002). Heimler et al. (2013) analysed various flavonoid and hydroxycinnamic derivatives present in aqueous turnip extracts by HPLC, as shown in Table 1. Flavonoids may reduce the potential risk of cardiovascular, cancer and inflammatory ailments in humans. Sinapic, ferulic and caffeic acids, kaempferol 3-O-sophoroside-7-O-sophoroside, kaempferol 3,7-O-diglucoside, isorhamnetin 3,7-O-diglucoside, kaempferol 3-O-(feruloyl/caffeoyl)-sophoroside-7-O-glucoside, kaempferol 3-O-sophoroside, 1,20-disinapoyl-2-feruloyl gentiobiose, kaempferol 3-O-sophoro-side-7-O-glucoside, 3-p-coumaroylquinic, 1,2-disin-apoylgentiobiose, isorhamnetin 3-O-glucoside and kaempferol 3-O-glucoside are the phenolic compounds found in the stem, leaves and flower buds of the turnip. Likewise, Sinapic and ferulic acids and their by-products were present in vestigial amounts in the analysis of turnip roots. Isorhamnetin 3-O-glucoside, 1,20-disinapoyl-2-feruloyl gentiobiose, kaempferol 3,7-O-diglucoside, kaempferol 3-O-sophoroside, 1,2-disinapoylgentiobiose, kaempferol 3-O-glucoside and isorhamnetin 3,7-O-diglucoside were the compounds in common when compared with the results obtained for the *B. rapa* variety (Kumar & Andy, 2012; Romani et al., 2006a). These phenolic moieties were found in various turnip extracts, with 10 to 19g/kg and 8 to 13g/kg on a dry weight basis in the flower buds and leaves and stems, respectively (Ludwig et al., 2011). The leaves and stems exhibited similar profiles, with kaempferol 3-O-sophoroside-7-O- glucoside, kaempferol 3-O-(feruloyl/caffeoyl)-sophoroside-7-O-glucoside, isorhamnetin 3,7-O- diglucoside and isorhamnetin 3-O-glucoside present in larger amounts, whereas 3-p- coumaroylquinic acid, 1,2-disin-apoylgentiobiose and 1,20-disinapoyl-2-feruloylgentiobiose were present in minor quantities (Rafatullah et al., 2016). Likewise, sinapic acid and kaempferol 3-O-glucoside were present in larger amounts, whereas caffeic acid and kaempferol 3-O-sophoroside-7-O-sophoroside were found in smaller amounts in the turnip flower buds. However, turnip flower buds showed significantly lower amounts of the pair kaempferol 3-O-sophoroside-7-O-sophoroside plus caffeic acid, and presented significantly larger amounts of sinapic acid, 1,20-disin-apoyl-2- feruloylgentiobiose and kaempferol 3-O-glucoside than the leaves and stems (Christensen, 2009). Similarly, despite quantitative differences noticed in the organic acid contents of different extracts from the same plant material, ketoglutaric, shikimic, citric, aconitic, malic and fumaric acids were found in almost all the turnip portions (Francisco et al., 2011b). However, the leaves, stems and flower buds contained significantly higher contents of organic acids (36 to 51 g/kg) than the roots (Fernandes et al., 2007). A smaller amount of aconitic acid was found in the stem, roots and leaves, and shikimic acid was a minor compound in the flower buds (Daryoush et al., 2011). Similarly, ketoglutaric and citric acid showed higher concentrations in the flower buds, while malic acid was a major acid in all the edible portions of the turnip. Turnip root showed higher concentrations of malic acid (81%), followed by the leaves and stems (65%) and the flower buds (44%). Aconitic acid was higher in the flower buds (14%) and relatively lower in the roots (2%). It has been reported in the literature that shikimic, citric, aconitic, malic and fumaric acids show positive activity against gram negative bacteria (Sousa et al., 2008). On the other hand, shikimic acid is generally used as the starting material for the industrial synthesis of the antiviral drug Oseltamivir (this drug is effective against the H5N1 influenza virus and is administered to treat and prevent all known strains of the influenza virus) (Bradley, 2005; Bochkov et al., 2012). In addition, a Chinese research team has synthesized a shikimic acid derivative, triacetylshikimic acid, which exhibits anticoagulant and antithrombotic activities (Huang et al., 2002). In another study, citric acid showed antioxidant and anti-inflammatory effects when administered orally at 1–2 g/kg in brain tissue. Similarly, citric acid also demonstrated a beneficial hepatic protective effect when administered in the same dose range (Abdel-Salam et al., 2014).

Table 1. Turnip phenolic compounds.

Phenolic compounds	Identified by	References
Kaempferol 3-O-sophoroside-7-O-glucoside	HPLC-DAD	Fernandes et al. (2007), Francisco et al. (2009), Cartea et al. (2010), Heimler et al. (2013)
Kaempferol 3-O-(feruloyl/caffeoyl)-sophoroside-7-O-glucoside		
Kaempferol 3,7-di-O-glucoside		
Isorhamnetin 3,7-O-diglucoside		
Sinapic acid		
Hydroxycinnamoyl gentiobiosides	HPLC-DAD/MS	Romani et al. (2006a)
Kaempferol-3-O-glucoside		
Quercetin-3-O-(sinapoyl)-sophotrioside-7-O-glucoside		
Hydroxycinnamoylmalic acids	LC/MS	Lin & Harnly (2010)
Hydroxycinnamoylquinic acids		

5 Bioactive substances & pharmacological perspectives

The beta cystathionase present in turnip contributes to five different metabolic pathways listed as nitrogen, methionine, cysteine, selenoamino acid and sulphur metabolism (Milkowski et al., 2004). The potential risk of cardiovascular diseases and cancer can be reduced by the dietary phytonutrients found in turnips. Agati & Tattini (2010) illustrated that research on the chemoprotection approach has focused on the biological activity of plant-based flavonoids, isoflavones, polyphenols, terpenes and glucosinolates. Batista et al. (2011) suggest that the turnip phenolic compounds may act as a natural pesticide, helping to improve the resistance against different parasites and pathogens. The phenolic compound contents in the turnip can be affected by the degree of ripeness, cultivar and germination (Ayaz et al., 2008). Moreover, Dergal et al. (2002) reported that tannins may affect iron bioavailability and protein absorption by forming insoluble complexes with the protein as well as with minerals (Gemede & Ratta, 2014; Delimont et al., 2017).

Functional and nutraceutical foods have become key issues in behavioural nutrition and diets (Batista et al., 2011). Recently, the increase in the use of vegetables and fruits in the consumer diet has not only significantly improved consumer health, but also decreased the chances of chronic disorders. In addition to basic nutrition, foods obtained from plants provide substantial quantities of bioactive compounds, which help to maintain consumer health (Dillard & German, 2000). The edible portion of turnips i.e. stems, roots, leaves and flower buds, contain 14 different phenolic compounds. Isorhamnetin 3,7-O-diglucoside, kaempferol 3-O-sophoroside-7-O-glucoside, isorhamnetin 3-O-glucoside and kaempferol 3-O-(feruloyl/caffeoyl)-sophoroside-7-O-glucoside are the foremost phenolic compounds, whereas malic acid is the main organic acid found in larger amounts in the turnip. In addition to these, the turnip flower buds show significant antioxidant capacity. A minute quantity of oxalic acid (0.21 g per 100 g) is found in the top greens and roots of the turnip, which can cause oxalate stones in the urinary tract. Thus sufficient water intake is advised to sustain a normal urine output in subjects with a higher risk for kidney stones (Lin & Harnly, 2010). The bioactive non-nutritive compounds can also contribute to the organoleptic properties of the vegetables and fruits (Francisco et al., 2009). Romani et al. (2006b) reported that the organic and phenolic acids of the brassica genus and their by-products have been widely investigated.

6 Therapeutic proteins in transgenic cultivars

Recently, researchers have shown more interest in the production and delivery of therapeutic proteins. From this perspective, both the alpha- and beta-interferons, which are therapeutic proteins formed under specific conditions i.e. fermentation, may be significantly important against various ailments such as cancer, heart attacks, hepatitis A and B, anaemia and diabetes (Auger et al., 2010). These proteins are being produced by means of microbial fermentation in cell cultures in transgenic turnip roots and in some other products. Numerous therapeutic proteins are mostly produced by parenteral routes. In order to attain maximal efficacy with minimal risk, various novel methodologies have been explored and designed to obtain these therapeutic proteins (Muheem et al., 2016).

7 Hepatoprotective role

In recent times, the trend for taking herbal medicines has been increasing day by day, with a decrease in the trend for conventional therapy (Rivera et al., 2013; De-Smet, 2002). This growing demand is due to the broad spectrum of health benefits offered by these herbal therapies against various disorders. In Arabia and Unan, the turnip is used as traditional medicine for various diseases such as constipation, chronic gastritis, cholecystolithiasis, liver diseases and cancer (Pithford, 2002; Hartwell, 1971). A study was carried out to probe the antihepatitic and antioxidative role of turnip in rats with CCl_4 (carbon tetrachloride) induced liver damage (Bhinu et al., 2009). Nonprotein-sulfhydryl activities were shown to decrease drastically in the CCl_4 treated rats when compared with the normal group. Treatment with turnip juice restored the decrease in these activities produced by the CCl_4, tending towards normalization with the highest dose (16 mL/kg) (Nair et al., 2000). Likewise, the aqueous extract of *Brassica rapa* chinensis (250, 500 mg/kg) decreased the oxidative stress induced by tert-butyl hydroperoxide (t-BHP) in rats. The treatment with the aqueous extract of Brassica rap chinensis significantly combatted the oxidative stress produced by t-BHP in the hepatic tissues, as evidenced by a marked improvement in the antioxidant status and suppressing lipid peroxide levels. The results obtained were dose dependent, with the 500 mg/kg bw dosage of *Brassica rapa* chinensis aqueous extract showing the greatest potential in curbing toxic effect of t-BHP (Kalava & Mayilsamy, 2014; Al-Snafi, 2015). Some Brassica species, including turnip, were previously investigated for their anti-carcinogenic activity (Kristal, 2002). Hence, Brassica vegetables are consumed for health improvement, which is related to their antioxidant activity (Plumb et al., 1996), and the foremost antioxidants of turnips and related vegetables are probably the phenolic compounds, for example, flavonoids. Thus, these polyphenols scavenge the free radicals and break the propagation chain (the second defence line) or inhibit chain initiation (Shi et al., 2009; Robards et al., 1999).

8 Ethanolic extract against hepatic injury in diabetics

Nowadays, the turnip has gained even greater interest for its anti-diabetic effect, due to the finding of numerous bioactive compounds such as flavonoids, phenylpropanoid derivatives, indole alkaloids and sterol glucosides (Romani et al., 2006a). Different classes of flavonoids have positive effects on diabetic patients in different ways (Podsedek et al., 2006). For instance, isorhamnetin plays a vital role in inhibiting the activity of aldose reductase, which is directly related to complications in diabetics. Likewise, kaempferol has an important anti-diabetic role by increasing glucose absorption in the rat muscles and lowering the glycemic level (Rajesh & Latha, 2014). Moreover, quercetin lowers the blood sugar level and boosts the plasma insulin level in diabetic rats due to streptozotocin (Srinivasan et al., 2018). A similar study explored the finding that the ethanolic extract of turnip roots had an antidiabetic effect in diabetes mellitus type 2, by increasing glucose and fat metabolism (Sen et al., 1993). The antioxidant potential of turnip is attributed to the frequently existing flavonoids and hydroxycinnamic acid derivatives (Syed et al., 2004). Likewise, the ethanolic extract of turnip roots exhibits a protective effect against the initial hepatic injuries produced in alloxan-induced diabetic rats. It has also been reported in the literature that the ethanolic extract of turnip lowered the serum biomarker levels of hepatic injury (Nouairi et al., 2008), and it would appear that the ethanolic extract has a protective effect on the early diabetic hepatopathy in rats with experimentally induced diabetes (Daryoush et al., 2011).

9 Effect of turnip juice on phenobarbital-induced sleeping time

It was reported in the literature that the administration of turnip juice significantly lowered the phenobarbital-induced sleeping time. In addition, it has been shown that the CCl_4 induced depletion of hepatic Net Positive Suction Head (NPSH) is significantly prevented by the ingestion of fresh turnip juice. Furthermore, the inhibitory effect of the juice on the CCl_4 induced prolongation of sleeping time, suggests that the juice constituents can reverse the damage exerted by $CC1_4$ on cytochrome P450, which is involved in the metabolism of phenobarbitone (Husken et al., 2005). It was concluded that turnip juice could inhibit CCl_4 induced liver damage in rats, possibly through its antioxidant mode of action, which supports earlier findings on other Brassica species. These findings also substantiate the claims of herbal and Unani medicine practitioners who use turnip to treat liver ailments (Francisco et al., 2011b).

10 Conclusion

Turnip is an easily accessible and plenteous dietary source of biologically active compounds. However, due to the small quantities of phenolic moieties and antioxidant ability, the turnip root seems to be the least interesting edible part. It is known that this plant contains organic acids, lipids, amino acids (free and in proteins), free sugars and minerals which play an important role in sustaining the fruit and vegetable quality as well as in determining the nutritive value of the plant in the human diet. Furthermore, turnip also has various pharmaceutical aspects such as a positive role against hepatic injury in diabetics, a heptoprotective role etc. These beneficial properties have been partly attributed to biologically active compounds present in the turnip, which show considerable antioxidant activity.

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