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EVALUATING CARROT AS A FUNCTIONAL FOOD

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Abstract: *Consumers have already tended to choose natural plant crops over processed plant produces, like carrot (Daucus corota L.) which is one the very nitrous horticultural crops enjoyed by all ages. Although carrot is rich in fiber and minerals, it is primarily cherished for high beta-carotene content. Moreover, the root contains some other bioactive compounds including other forms of carotenoids, phenolic compounds, vitamin C and polyactylenes. Carotenoid especially beta-carotenes is known for supplying vitamin A and a strong antioxidant activity. Phenolic compounds present in carrots such as chloregenic acids have also antioxidant activities as well. Carrots contain considerable quantity of ascorbic acid which possesses an antioxidant activity and also takes a part some in biological processes. Carrot roots have polyacetylenes, once viewed as toxicants due to being potent skin sensitizers and irritants, which are neurotoxic at high concentrations, more recently they have been considered bioactive compounds. The phytochemical compounds present in carrots may be used as complementary medicine for the prevention and treatment of a number of diseases and disorders. This review explores some major phytochemicals and their pharmacological features present in carrot roots.*

Key words*: Apiaceae, medicinal plant, Vitamin C, beta-carotene, chlorogenic acids*

1. Introduction

Carrot has been widely cultivated since ancient times, and it is one of the 10 most economically valuable crops in the world [1]. An estimated 43 million ton carrots (combined with turnip) are produced annually worldwide, and China is the largest producer followed by Uzbekistan and Russia [2]. In Turkey, the annual carrot production value is about 570,000 tons, and Konya province is the leading producer (355,652 tons) followed by Ankara (132,880 tons) and Hatay (53,121 tons) [3]. Carrot is taught to be originated from Afghanistan [4]. Modern-day carrots are very different from ancestral ones with reduced bitterness, elevated sweetness, reduced endocarp portion [5]. Orange colored cultivars are widely cultivated around the world, however, red, black, pink, purple, yellow and white colored carrots are cultivated as well. Carrots are used for a broad range of ways including fresh, fired, steamed, blanched, or cooked in stews, soups, cakes, and pies. Moreover, from carrots, juices and baby foods are

prepared. Fresh-cut carrots products such as planed, round and finger (baby or mini carrot) can be found as well.

Carrot is considered as one of the high nutrient quality crops, and therefore, it is consumed by people of all ages. The vegetable is good source of fiber, carbohydrate and some minerals. However, the carrot is famous for its rich beta-carotene content. Due its unique structure consisting of 11 conjugated double bonds and a β-ring at each end of the chain, beta-carotene delivers provitamin A and also carries very powerful antioxidant activity [6]. Other carotenoids found in carrots are alpha-carotene, lutein, zeaxanthin, and lycopene [1]. Besides its rich alfa- and beta-carotene contents, the root contains a wide range of bioactive compounds including chlorogenic acids [7], quercetin, luteolin, kaempferol, myricetin [8], cyaniding, pelargonidin and peonidin [9] as phenolic compounds; Falcarinol, falcarindiol, and falcarindiol-3-acetate [10,11] as polyacetylenes; and vitamin C [12].

This review aims at highlighting carrot root phytochemicals and their health-giving properties.

2. Nutritional value of carrots

Usually orange-colored carrots have been used for quantifying nutritional value of carrots. Carrot roots contain approximately 88% water, 1% protein, 7% carbohydrate, 0.2% fat, and 3% fiber [10]. The carbohydrate part is mainly formed by simple sugars, chiefly sucrose, glucose, and fructose, with a minor amount of starch [7]. The roots are rich in fiber including cellulose (50%), hemicellulose (92%) and lignin (4%) [13]. The vegetable is a good source of minerals such as calcium, magnesium, potassium, phosphorous, sodium, and some other trace minerals [14]. Apart from recognized phytochemicals, carrot carries significant amount of Vitamin C, E, and K, folate and choline [12]. Black carrots have significant amount of water-soluble anthocyanins which are used for natural food colorants as red, purple or blue [15]. Carrot contains more than 90 aromatic compounds that are primarily mono- and sesquiterpenes, which contributes to its characteristic aroma [16, 17] which is savored by not only children by also adults.

3. Carrot phytochemicals

Carotenoids, phenolic compounds including anthocyanins, vitamin C and polyactylenes are the predominant phytochemicals isolated from carrot roots (Tab. 1).

Table 1. Major phytochemicals present in carrot roots

Carotenoids	Alfa-carotenes
	Beta-carotenes
	Lutein
	Beta-cryptoxanthin
	Lycopene
	Zeaxanthin
Phenolics	Chlorogenic acid derivatives
	P-hydroxybenzoic

	Caffeic acid
	Luteolin
	Keampferol
	Myricetin
	Cyaniding
	Pelargonidin
	Peonidin
Polyacetylenes	Falcarinol
	Falcarindiol
	Falcarindiol-3-acetate
Vitamins	Ascorbic acids (Vitamin C)
	Vitamin E
	Vitamin K
	Folate (Vitamin B_1)
	Choline (Vitamin B_4)

The carrot roots contain a very high amount of carotenoids which are considered high-value bioactive compounds known for health-giving properties. Color of the carrot in most cases defines carotenoid types and quantity: for example, orange-colored carrot root possesses high amount of alfa and beta carotene, red-colored carrot ones does high amount of lycopene, and yellow-colored ones does high amount of lutein [18]. Orange-colored cultivars are very rich in carotenoids especially beta-carotene (ca. 8.3 mg 100 g-1 fw) which is the predominant phytochemical present in carrot [19]. Besides beta-carotene, other from carotenoids including alpha-carotene, lutein, zeaxanthin, and lycopene are also found in carrot roots [1].

The leading phenolic compounds present in carrot roots are chlorogenic acids [7] followed by quercetin, luteolin, kaempferol and myricetin [8] as flavonoids; and cyaniding, pelargonidin and peonidin as anthocyanins [9]. Black-colored carrot cultivars bears abundant amount of flavonoids than other cultivars [1, 18]. The predominant chlorogenic acids presented in carrot roots are 5´-caffeoylquinic acid, 3´¬caffeoylquinic acid, 4´-p-coumaroylquinic acid, 3´,4´-dicaffeoylquinic acid, 3´,5´-dicaffeoylquinic acid, and others [20].

Carrots contain considerable quantity of vitamin C (5.9 mg 100 g-1 fw [12]. The Vitamin C quantity found in carrots is higher compared to grapes, nectarines, pears, and plums, among others [1].

Carrot carries another group of phytochemicals called polyacetylenes which are widely distributed in Apiaceae family. Polyacetylenes contribute the bitter flavor formation in carrots. Types of polyacetylens present in carrot roots are falcarinol, falcarindiol, and falcarindiol-3-acetate [10, 11].

4. Pharmacological effects

Carrot root extracts have been reported to have anti-nocceptive, anti-inflammatory, hypoglycaemic, anti-diabetic, antioxidative and anticancer effects [21- 24].

Carrot is the richest beta-carotene source among fruits and vegetables. Beta-carotene is precursor of Vitamin A which is necessary for vision by converting neural transmission of light into vision and for visual dark adaptation [1, 25]. The other important function of Vitamin A includes the control of cellular development and body processes [1]. Vitamin A is converted to a hormone-like molecule retinoic acid which regulates some immune responses through gene expression and transcription [26].

Carotenoids have been clinically studied for an anti-cancer agent and found effective in animal models and in humans. Beta-carotene is a very strong antioxidant compound because of having 11 conjugated double bonds and a β-ring at each end of the chain, which may neutralize free radicals in lipophilic environment including membranes [7]. Extract obtained through hexane from red carrot has been found to have cytotoxic activity against human breast cell lines (MCF-7) [24]. Similarly, ethanol or acetone extracts from black carrot have been shown to have cytotoxic activity against the same cancerous cell lines [25].

Carrots contain another type of carotenoids lutein which implicated in preventing of age related muscular regeneration and reduced risk of atherosclerosis [28].

Carrots own significant antioxidant compounds including carotenoids, phenolics, vitamin C, and tocopherol. Antioxidants protect cells against free radicals generated in cells through metabolic activities or from environmental sources. Free radicals engage with vital biomolecules like lipids, lipids, proteins, or even DNA to start processes which may lead to chronic diseases such as cancer or cardiovascular diseases [1].

Carrots carries Ascobic acid which is well-known its antiscorbutic activity. Ascorbic acid is likely to possess preventative role against some diseases including cancer and cardiovascular diseases [1]. Furthermore, it takes a part of some biological processes including the suppression of enzymatic browning and the formation of nitrosamines, the decline of metallic ions, and the enhancement of the stability and utilization of folic acid and vitamin E [29]. Ascorbic acid also improves the absorption of iron to prevent anemia [30].

Carrots contain a group compounds, polyacetylenes which are widely found in Apiaceae family including falcarinol, falcarindiol, and falcarindiol-3-acetate [10, 11]. Recent in vitro studies indicated that polyacetylenes of carrots possess have anti-inflammatory activity in macrophages, biphasic stimulatory and cytotoxic effects on primary mammary epithelial cells, and cytotoxic activity in some cell lines [7, 31, 32]. Thus, once viewed as toxicants due to being potent skin sensitizers and irritants and are neurotoxic at high concentrations, more recently they have been considered bioactive compounds [10].

Cyanidin 3-xylosyl galactoside anthocyanin extracted from black carrots has been shown to be effective against Type-2 diabetes [33]. The phytochemical inhibits glucose metabolism related enzymes such as alpha-amylase and alpha-glucosidase [33].

Ethanol extracts from black carrot have exhibited an antibacterial activity against food-borne pathogens including *Bacillus cereus* and *Staphylococcus aureus* [17].

5. Conclusion

In this review, we present carrot roots containing some valuable biologically active compounds including carotenoids with provitamin A activity, phenolic compounds, vitamin C and polyactylenes which possessing antioxidant activities and other health-giving effects. Thus, we suggest that

consumption of carrots does increase intake of health promoting phytochemicals end eventually may impede some diseases or disorders associated with these phytochemicals. However, more studies are required for effectiveness and safety of the phytochemicals.

We recommend carrot culture and consume in Turkey should be supported by both government and media. Turkey is one of the rich countries in terms of carrot diversity including varieties, cultivars and genotypes, thus, both universities and research institutes should do more researches on carrots in order not to stay behind other developed countries. We also advice that carrot producers to be more vocal on health promoting effects of carrots, which might result not only an increase in consumption but also revenue.

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