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CARROT – APPLICATION IN FOOD INDUSTRY AND HEALTH BENEFITS– REVIEW

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Abstract: Carrot (*Daucus carota* subsp. *sativus*) is widely used in the food industry under different forms as raw, cooked, dried, or as juice. Carrots have a high content of proanthocyanidins, carotenoids, saponins, and fibers. Due to the high content of biologically active compounds, carrots have an antioxidant, cardiovascular and anticancer effect, reducing the occurrence of degenerative diseases. Nonetheless, because of their high water content of about 88%, it can deteriorate rapidly. This root vegetable can be used in the food industry to obtain various types of products with a high fiber content, in order to increase the water absorption. Another application of carrots might be represented by the flavoring industry in the form of essential oils with high antimicrobial activity. Vegetable products display some nutritional and sensory characteristics, with applicability in obtaining edible biodegradable bioplastics. Consumption of carrot-containing foods, rich in polyphenolic compounds, brings many benefits to human health and is effective against various diseases due to their antimicrobial, anti-inflammatory, antioxidant activities. Nonetheless, in terms of the food applicability of carrots, new opportunities will arise in the future, opportunities related to the carrot processing industry which generates a lot of waste in the form of pomace and shells, which can generate economic and environmental problems.

Keywords: carrot, bioactive compounds, food product, health benefits

Introduction

Carrot (*Daucus carota* L.) is reckoned to be one of the most widely known, consumed, and grown root vegetable of the *Umbelliferae* family known also as *Apiaceae*, throughout the world. It is an important source of phytonutrients and dietary fibers (Arscott *et al*., 2010). The fresh carrot root contains ≈ 7% carbohydrates, 3% fibers, 1% proteins, and 0.2% fats (Christensen and Brandt, 2006), 88% water on a wet basis and may degrade easily during storage, this being the main cause

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of the economic losses of cultivators (Wang *et al*., 2018). Given its perishable nature, selecting the most appropriate carrot preservation method is important to retain the nutritive values for a better commercialization (Guo *et al*., 2020).

The total production of carrots (including turnips) was 44.76 M tons in the world in 2019 (http://www.fao.org/faostat/en/#data). China, Uzbekistan, and the USA were the top three producer countries with around 21.38 M tons, 2.77 M tons, 2.26 M tons, respectively, Asia and Europe have the highest production share in carrots, with 29.03 M tons and 8.53 M tons, (http://www. fao.org/faostat/en/#data).

Carrots display a large variety of colour palette. Among the main colours this root vegetable has are counting also white, yellow, orange, red, and purple. According to the studies conducted by Xu et al., (2014), the higher content of anthocyanins was found in the purple carrots variety. There are a few known anthocyanins identified in the taproots of orange carrots, and no anthocyanins were measured in yellow carrot roots (Xu et al., 2014).

Carrot is widely used in the food industry as an ingredient in various products. This led to the development of new effective drying techniques and longer shelf life (Keser *et al*., 2020). In addition to the fresh consumption, carrots can be consumed in dried and powdered forms, being used in order to increase the colour and nutrient content of different food products such as sausages, cakes, soups, baby foods, confectionery, jam, and fruit juices (Mizgier *et al.*, 2016; Ismail, 2017; Akande *et al*., 2018; Ferrario *et al*., 2018; Alvarado-Ramirez *et al*., 2018; Ergun and Susluoglu, 2018).

The use of the drying process on carrots in the food industry is expanding, the principal area being in the production of bakery products and extrudates. There is a wide range of drying methods: hot air drying, freeze-drying, microwave drying, vacuum drying, and infrared drying (Rajkumar *et al*., 2017; Lau *et al*., 2018; Soysal *et al*., 2018; Ye *et al*., 2019). The most important and necessary thing to know when using the drying process is how to preserve the flavor and color as well as to prevent undesirable aroma formation (Li *et al*., 2010; Hiranvarachat *et al*., 2011).

The freeze-drying method is effective but expensive compared to other drying methods, and also the conventional drying processes conventional drying methods lead to numerous changes in colour, the content of biologically active compounds, and flavour of the finished product during drying (Keser *et al*., 2020).

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One of the short, effective, carrot drying methods is microwave drying (Keskin *et al*., 2019). Is a method used often since it is saving time and energy, as well as is enabling the production of high-quality final products (Kubra *et al*., 2016).

Application of carrot in food industry

Daucus carota L. is a very healthy vegetable due to its benefits to human health, its nutritive value, and healing properties (Doymaz, 2004; Gamboa-Santos, *et al*., 2012). Researchers conducted in the last years have seen significant increases in carrot consumption and carrot-based products (Hiranvarachat, *et al*., 2011). It is well known that carrots are seasonal vegetables, available only at certain times of the year. Given the fact that the moisture content of carrots is higher than 80%, they wither quickly after harvest if not stored properly (Togrul, 2006). In order to extend this root availability, several conservation processes were subjected to analysis. The dehydration process is important, due to the fact that it can extend the shelf life of vegetables, it can preserve the nutritional quality, but it can also lead to a diversified supply of food for consumers (Prakash, *et al*., 2004). Moreover, it reduces the weight and volume of carrot-based products, thus minimizing the costs of packaging, storage, and transportation, while also allowing the product to be stored at ambient temperatures (Baysal, *et al*., 2003). Currently, dehydrated carrots are used as an ingredient in making instant soups but also for healthy snacks without oil (Lin, *et al*., 1998).

Because vitamin A deficiency is a constant health problem in developing countries (Schmidhuber *et al*., 2018), one way to fight this is to increase the concentration of provitamin A-type carotenoids found in vegetables. This can be done by consuming vegetables that are naturally rich in carotenoids, or consuming foods such as golden rice and super banana (Tang, *et al*., 2009; Waltz, 2014), or modifying the phytochemical composition of the crops by acting on the environmental conditions. According to the studies conducted by Atkinson, *et al*., (2005) the pre- and post-harvest practices can increase the apparent concentrations of biologically active compounds such as provitamin A (Saini and Keum, 2018). It is specified "apparent" concentration due to the fact that the conducted researches do not say for sure if there was a real increase in the concentration of these compounds or if the structural changes of the plants in question led to increased extractability of these compounds, leading to high concentrations during phytochemical quantification (Hammaz *et al*. 2021).

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In Romania, carrot pulp represents a common agro-food waste. This type of food waste has large quantities of bioactive compounds and fibers. Anthocyanins (in the case of purple carrots) and carotenoids (in the other cases) are the main compounds accountable for the colour, aroma, and bitterness of carrots (Gonçalves, *et al*., 2010). More than that is demonstrated that polyphenolic acids have antioxidant capacity, and anthocyanins are responsible for reducing the occurrence of cardiovascular heart disease (Arscott and Tanumihardjo, 2010).

There is insufficient information on the utilization of the polyphenolic compound of Romanian agro-industrial waste. Reusing this type of waste could help to diminish the dispute about the solid-waste disposal problem (Vodnar *et al*., 2017).

Therefore, there are ways to use the vegetable waste from the food industry and to develop new value-added products. Easily spoiled vegetable products can be transformed into new ingredients or nutraceuticals, after which can be added to various foods or beverages (O'Shea *et al*., 2012; Jiang *et al*., 2013).

It is very possible that new products, obtained from the vegetable industry residues will not have an impact on food waste and human health, if consumer demand for such products is low. An example of such a product is represented by carrot powders, which have been incorporated into Indian products such as chapati and halwa (Singh and Kulshrestha, 2008). Another example is carrot pomace (a by-product resulted after carrot juice extraction) that has been used to increase the nutritional value of ready-to-eat snacks (Alam, *et al*., 2016).

Ready-to-eat dried vegetable chips, have aroused the interest of food technologies for the last years, due to the combination of attractive sensory properties and a high concentration of phytonutrients, grouped in a dry tissue matrix, which offers a unique opportunity to obtain a functional product in an attractive form (Vinson, *et al*., 2005; Konopacka *et al*., 2010b; Dueik, *et al*., 2013). Among the most widely consumed vegetable varieties worldwide, carrots are considered to be one of the most promising raw materials for obtaining crispy chips (Skrede *et al*., 1997; Sulaeman *et al*., 2001; Albertos *et al*., 2016). Due to the high amount of carotenoids, this sort of snack could be an interesting proposal for consumers eager to increase their daily intake of vegetables. Typically, two types of technologies can be used to turn sliced carrots into crunchy snacks, namely: frying in oil in a low-pressure medium (Sulaeman *et al*., 2001; Albertos *et al*., 2016) followed by a drying process; either by hot air drying (Plocharski and Konopacka, 2002;

Dueik *et al*., 2013), or a combined microwave-vacuum approach (Lin, *et al*., 1998; Cui, *et al*., 2004).

In all the above cases the carrot slices are subjected to thermal processes, leading to strong dehydration of the tissue matrix, which may cause major carotenoids degradation, mainly due to the isomerization and oxidation reactions of β-carotene, that can substantially decrease biological activity in the final products (Hiranvarachat, *et al*., 2011; Dueik *et al*., 2013).

The current trend for a healthy diet, eliminating any fried salty snacks, has led researchers to study in the direction of developing and improving the technology of dried vegetable snack production (Konopacka *et al*., 2010b; Hiranvarachat *et al*., 2011).

The studies of Akubor and Eze, (2012) revealed a fortified cake formulation with contains dried carrot powder which increases the nutritional value. Also Salehi, *et al*., (2016) used carrot powder in order to produce rich fiber sponge cake. This study highlighted that the cake had β-carotene and moisture contents, and also the ash and the density values higher than those for protein and carbohydrate contents. Different research studies reported that the fiber content and also water absorption of the cakes were increased after carrot powder addition. Kamiloglu *et al*., (2017) reported that the addition of carrot pomace increased the nutritional values of the cake by increasing the content of bioactive compounds and total antioxidant capacity aside from affecting the physical and sensorial aspects.

Health benefits of carrot

Numerous health benefits related to vegetable consumption can be attributed to the presence of carotenoids (Van Duyn and Pivonka, 2000), carrots being an important source of provitamin A carotenoids (Block, 1994; Goldbohm, *et al*., 1998). According to the latest studies, vitamin A remains one of the most widespread problems in terms of nutrient deficiencies in developing countries (West, 2002; Singh and West, 2004). Carotenoids possess antioxidant activity, thus having an important role in protecting against free radical-mediated diseases (Basu, *et al*., 2001), such as cardiovascular diseases (Kritchevsky, 1999; Giordano *et al*., 2012; Maria, *et al*., 2015), macular degeneration, and cataract (Beatty *et al*., 2000; Gale *et al*., 2001; Delcourt *et al*., 2006). Numerous research studies have shown that these biologically active compounds have anti-cancer properties (Gerster, 1993; Khachik, *et al*., 1995; Tamimi *et al*., 2005) helping to prevent oxidative cell damage, inhibit cancer cell proliferation, induce apoptosis, and modulation of the activity of different transcription factors (Sharoni *et al*., 2012). Some studies suggest that carotenoids may improve cognitive function (Johnson, 2012; Lindbergh *et al*., 2017) and reduce obesity (Bonet, *et al*., 2015; Canas *et al*., 2017).

The growing interest of researchers in carotenoids has focused mainly on the activity of provitamin A containing β-rings, due to the fact that vitamin A deficiency is one of the major micronutrient deficiencies encountered worldwide. In mammals, provitamin A-type carotenoids are converted to retinol and other derivative compounds, with an important role in vision and gene regulation, respectively (Grune *et al*., 2010). Moreover, carotenoids have biological activities with beneficial effects on health but are still insufficiently studied (Maiani *et al*., 2009; Howard *et al*., 2017; Wang, 2012; Yamaguchi, 2012). Benefits to human health associated with increased carotenoid intake include strengthening the immune system and reducing the risk of developing cardiovascular disease or degenerative diseases such as type 2 diabetes, obesity, various cancers: breast, cervical, ovarian, colorectal (Landrum *et al*., 2001; Cooper, 2004; Hamer *et al*., 2007; Britton *et al*., 2009; Fernández-García *et al*., 2012; Bonet *et al*., 2015; Leermakers *et al*., 2016; Milani *et al*., 2017;). Carotenoids can be used as ingredients in various products exerting positive effects on cognitive functions (Johnson, 2012; Hammond, 2015; Lindbergh *et al*., 2018), but also in cosmetic products with photoprotective effects (Meléndez-Martínez *et al*., 2018).

There are numerous studies focused on epidemiological data linking carotenoid intake to the human health benefits of carotenoid use. These studies have also shown that a carotenoid intake of more than 20 mg/day of β-carotene can have side effects, including a high risk of developing cancer and even death (Bjelakovic *et al*., 2012). The studies that tested this hypothesis are alpha-tocopherol beta-carotene (ATBC) (Blumberg *et al*., 1994) and beta-carotene and retinol efficacy trial (CARET) (Omenn *et al*., 1996). Surprisingly, when smokers and those exposed to asbestos consumed additional β-carotene, they had an increased risk of developing lung cancer (Omenn *et al*., 1996; Albanes *et al*., 1996). The CARET study also reported that dietary supplementation with β-carotene led to an increase in mortality due to the development of coronary heart disease (Blumberg *et al*., 1994). The results of the ATBC and CARET studies are in contrast to a study performed on male non-smokers, whose diet was supplemented with 50 mg β-carotene/day (Hennekens *et al*., 1996). In this case, the supplementation did not lead to any negative results (Hennekens *et al*., 1996). Similarly, the Chinese intervention study in Linxian population conducted mainly on non-smokers, reported prevention effects against stomach cancer when they

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supplement the subject's diet with vitamins, minerals, plus 15 mg β-carotene/day (Blot *et al*., 1995). These results were an important factor in the health benefits of carotenoid consumption, highlighting that the dosage, the form of administration (dietary matrix or supplement), the duration of treatment, the combination with other nutrients and the health of the study subjects (e.g., healthy vs. sick, nutritional status) are very important (Grune *et al*., 2010; Tang, 2010). In any case, it is important to know that dietary supplements that contain any type of carotenoids (natural or synthetic) are not as effective in obtaining health benefits as the intake of carotenoids conferred by food consumption, where there is some interaction with other cellular compounds.

Studies in animals and cell cultures have shown that retinoic acid has had an impact on the developmental and biochemical processes that influence mammalian adiposity. Such as: adaptive thermogenesis, adipocyte differentiation, lipolysis, lipogenesis, and fatty acid oxidation in tissues such as liver, white and brown adipose tissue, and skeletal muscle (Bonet *et al*., 2012).

The supplementation with β-carotene of mice feed reduces adiposity in a BCO1-dependent manner (beta-carotene 15,15'oxygenase) (Amengual *et al*., 2011). Other carotenoids with anti-fat activity used in preclinical studies include β-cryptoxanthin, fucoxanthin and astaxanthin (Landrum *et al*., 2001).

Lutein, zeaxanthin, and meso-zeaxanthin, accumulate preferentially in the retina thus improving the health of the eye. It is proven that lutein and zeaxanthin have a protective role against macular degeneration, a major cause of blindness in the elderly (Carpentier *et al*., 2009; Chew *et al*., 2014; Bernstein *et al*., 2016; Mares *et al*., 2016). They also provide cognitive benefits accumulating in the brain tissue (Johnson, 2012; Hammond, 2015; Lindbergh *et al*., 2018).

According to Akhtar *et al*., (2017), black carrot also display a lot of health benefits, as are described in Table 1.

Table 1. Health benefits displayed by polyphenols found in carrots (Akhtar *et al*., 2017)

Carrot	Dosage	Effects	References
Cancer HT-29 and HL-60	0.0 – 2.0 mg/mL	80% inhibition of colorectal adenocarcinoma (HT-29) and promyelocytic leukemia (HL-60) cells	Netzel *et al*., (2007)
Neuro cancer	6.25 μg/mL	Reduces MCF-7 SK-BR-3 and MDA-MB-231,	Sevimli-Gur *et al*., (2013)

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		Loweres HT-29, reduces PC-3, Lowered Neuro 2A cancer cell lines and VERO Highest cytotoxic activity against Neuro-2A cell lines exhibiting viability of 38-46%	
Brain cancer	170.13 µg/mL	IC-50 value for treatment of brain cancer without causing negative effects to normal healthy cells	Sevimli-Gur *et al*., (2013)
Breast cancer	8 fl.oz of fresh carrot juice daily for 3 weeks	Effective and enhance survival among breast cancer survivors	Butalla *et al*., (2009)
Cancer HT-29	14 µg of cy-3-glu equiv/mL	Chemoprotection of HT-29 cell proliferation	Jing *et al*., (2008)
Obesity	118.5 mg/day of anthocyanins 259.2 mg/day of phenolic acids	Changes in body mass Lowered LDL, TG, VLDL Enhanced HDL Lowered blood pressure	Wright *et al*., (2013)
Oxidative stress	Purple carrot juice	Reversed mechanism such as Developed Hypertension, cardiac fibrosis Endothelial dysfunction Impaired glucose tolerance, increased abdominal fat deposition Altered plasma lipid profile	Poudyal *et al*., (2010)
Oxidative stress (breast cancer women)	8 ounces of fresh BetaSweet (purple carrot)	Total plasma carotenoids increased by 1.65 µmol/L and in turn reducing oxidative stress in women previously treated for breast cancer	Butalla *et al*., (2012)
Diabetes	Purple carrot juice (0.5, 0.7, and 1 mg/mL)	Enhanced glucose uptake Increased insulin efficiency	Bhattacharya *et al*., (2014)

The health benefits of carrots are presented in the Figure 1.

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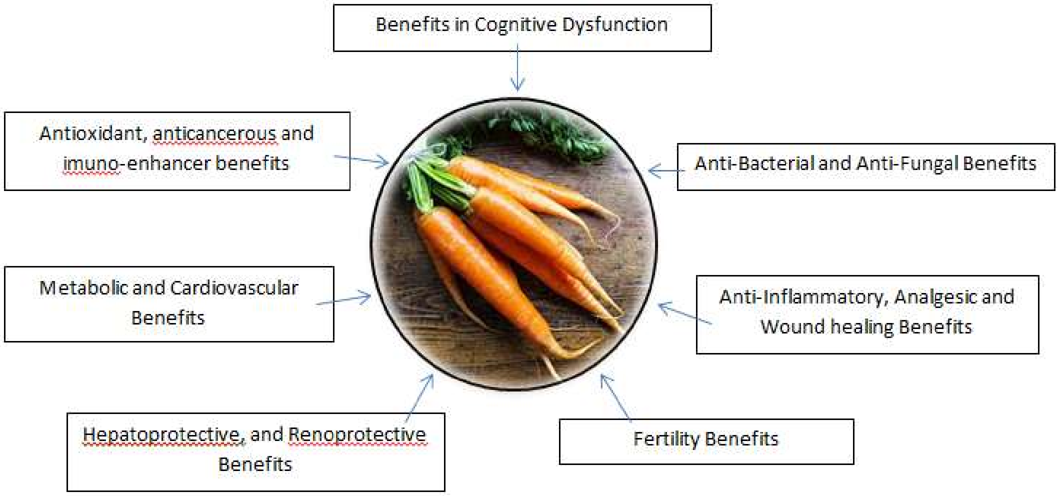

Figure 1. Carrots health benefits diagram

Antioxidant, anticancerous and imuno-enhancer benefits

The bioactive compounds and the vitamins found in carrots behave as antioxidant compounds, with anticancerous, and immuno-enhancer benefits. Carotenoids found in orange carrots are potent antioxidant compounds that can neutralize the effect of free radicals. The carotenoids are well known for their benefits, contributing to lowering the risk of some type of cancer (Dias, 2012a; Dias, 2012b). The study conducted by Zhang and Hamauzu, (2004) reported that polyphenolic derivates, present in the orange carrot play an important role as antioxidants, exerting an anticarcinogenic effect, anti-inflammatory effect, and others (Dias, 2012a; Dias, 2012b). Research by Zaini *et al*., (2011) highlighted the anticancerous effect of carrot juice extracts on leukemia cell lines. Purup *et al*., (2009) reported that different amounts of falcarinol or falcariol derivates found in carrot extracts have shown inhibitory effects on both normal and cancer cell proliferation. The cytotoxic activity exerted by falcarinol against several human tumor cell lines *in vitro* was investigated in different studies (Silva Dias, 2014). Ekam *et al*., (2006) assessed the immune-modulatory effect of carrot-extracted carotenoid using *in vivo* study on albino rats.

The research conducted by Yurtcu *et al*., (2011) showed that the consumption of a combination of ascorbic acid and b-carotene improves apoptosis in the human hepatocellular carcinoma cell line HepG2. It has also been reported that 10.20 μmol/L of beta-carotene induces bladder tumor cell apoptosis (Zhiping *et al*., 2019).

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Vitamin A deficiency can lead to damage to the eye's photoreceptors, resulting in vision problems. Consumption of β-carotene helps protect eyesight, especially night vision, but also protects against macular degeneration and cataracts (Dias, 2012a; Dias, 2012b). It is demonstrated the beneficial effect of carrot consumption on people that smoke, namely a low risk of developing lung cancer (Pisani *et al*., 1986) and prostate cancer (Wu *et al*., 2004). Hung *et al*., (2006) demonstrated the beneficial effect of carotenoids, polyphenolic compounds, and dietary fiber against bladder cancer and other carcinomas.

Metabolic and cardiovascular benefits

Given the high sugar content of carrots, nutritionists recommend eating carrots in moderation. This recommendation was made based on the carrot glycemic index (GI), published in 1981. Recent studies (Coyne *et al*., 2005) demonstrates a link between vitamin A-rich carotenoids and diabetes. According to this research, an increased level of blood glucose, as well as an increased level of insulin, was observed in participants with a lower amount of carotenoids in their blood. These findings suggest that carotenoids may help people with diabetes in order to control it. Chau *et al*., (2004) concluded in their studies that increased glucose uptake capacity, as well as reduced amylase activity of dietary fiber in carrots, could help control postprandial serum glucose levels.

The consumption of 200 mL of carrot juice containing 10 mg of β-carotene per day for eight weeks enhanced the serum beta-carotene levels in patients with type 2 diabetes (Ramezani *et al*., 2014). A study conducted on female goats who were given a dose of 50 mg/day of β-carotene for a long period resulted in an increased serum insulin level (Meza-Herrera *et al*., 2011).

The efficacy of purple carrot juice in the case of metabolic syndrome was demonstrated by Poudyal *et al*., (2010) reports. The purple carrot diet was supplemented in a high-carbohydrate, high-fat diet-fed rat model. Nicolle *et al*., (2003) reported that carrots showed cholesterol absorption mitigating effects in experimental carrot-fed rats. In addition, carrot consumption increased the vitamin E level in plasma and increased the ferric reducing ability of plasma Nicolle *et al*., (2003).

Muralidharan *et al*., (2008) investigations indicated that the carrot seed extract might have inotropic effects. The researchers concluded that this type of extract offers cardioprotection and muscle contraction regulation in rats.

Rats showed hypolipidemic activity when eating carrot seeds (Singh *et al*., 2010). It was observed that rats fed carrot seeds showed a reduction in total cholesterol and high-density lipoprotein cholesterol (HDL) and very-low-density lipoprotein cholesterol (VLDL) triglycerides compared to the control group of rats. In another study, these authors administered a diet enriched with lyophilized carrots to mice. The results suggested that carrot intake may have a protective effect against atherosclerosis-related cardiovascular disease. The effect may be due to the synergistic action of dietary fiber and compounds with antioxidant activity such as polyphenols present in carrots (Nicolle *et al*., 2003).

Carrots consumption by women has been proven to have many health benefits associated with a reduced risk of heart attacks (Gramenzi *et al*., 1990). Griep *et al*., (2011) studied the relationship between coronary heart disease (CHD) incidence and fruit and vegetables. Griep *et al*., (2011) determined that the protection against CHD increases with increasing the consumption of orange fruits and vegetables. Gilani *et al*., (2000) also studied the anti-hypertensive effect of two types of coumarins found in carrots using *in vitro* studies.

Hepatoprotectiv, and renoprotective benefits

Bishayee *et al*., (1995) studied the carrot extract and revealed that the containing bioactive compounds help protect the liver from the damage caused by the toxic effects of substances in the environment. Mills *et al*., (2008) studied the effects of antioxidant biologically active compounds in the pulp of four different varieties of carrots, the effect of provitamin A but also the antioxidant potential exerted of the carrot extract on the liver of gerbils.

The beneficial effects of carrot seed extract were also studied by Aydin *et al*., (2010). Singh *et al*., (2012) managed to do some *in vitro* antioxidant and hepatoprotective activity studies using methanolic carrot seed extracts. Thereby they concluded that the hepatoprotective activity of the extract was a result of the antioxidant potential of carrots. The reports of Singh *et al*., (2012) were in agreement with those of Rezaei-Maghadam *et al*., (2012). They highlighted the fact that the regular intake of ethanolic carrot seed extracts can lead to an improvement in the antioxidant activity in the liver tissue.

Benefits in cognitive dysfunction

In the category of cognitive dysfunctions can be included delirium, behavioral disorders, and dementia. Cognitive impairment is the leading cause of neurodegenerative diseases, such as Alzheimer's and dementia. Vasudevan *et al*., (2006) pointed out in their research that the administration of carrot seed extract reduced the activity of acetylcholinesterase, but also the level

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of cholesterol in mice. Moreover, they observed that the ethanolic extract from carrot seeds allowed the improvement of concentration capacity in mice, improving the memory, after administrating the extract for 7 days (Nadkarni, 1976; Vasudevan *et al*., 2010).

Anti-bacterial and anti-fungal benefits

The study of Rossi *et al*., (2007) showed that the essential oil of wild carrot leaves showed inhibitory action against *Campylobacter jejuni*, *Campylobacter coli* and *C. lari*. Another research study conducted by Kumarasamy *et al*., (2005) demonstrated that luteolin and luteolin 3'-O-glucoside had an inhibitory effect against *Bacillus cereus*, *Citrobacter freundii*, *Bacillus cereus* and *Lactobacillus plantarum*. Also, the growth of *Staphylococcus aureus* and *Escherichia coli* cultures was inhibited by compounds like luteolin and luteolin-4'-O-glucoside.

Misiaka *et al*., (2004) reported that carrot seeds oily extracts showed inhibitory effects on *Alternaria alternata*, carotol being responsible for the antifungal activity of these extracts.

Anti-inflammatory, analgesic and wound healing benefits

There are numerous studies that demonstrate the healing effects of carrot seed extract. For example, the research conducted by Vasudevan *et al*., (2006) suggested that carrot seeds have anti-inflammatory effect. Another study conducted by Mornin *et al*., (2003) showed that the compounds present in the carrot seed extract have anti-inflammatory properties due to the inhibition of cyclooxygenase and provided an increased anti-inflammatory effect compared to drugs such as Ibuprofen, Aspirin,etc.

In their research Patil *et al*., (2012) reported that animals treated with topical cream with different concentrations of ethanolic extract from carrot root, cream that showed significant decreases in wound area and scar size. The antioxidant and antimicrobial activities of the ethanolic extract of the carrot root, due to the presence of polyphenolic compounds have contributed to their healing property.

Fertility benefits

The effect of carrot seed extract on fertility is sex-dependent, with pharmacological studies showing that carrot seeds have infertility properties in women (Bhatnagar *et al*., 1995; Majumder *et al*., 1997; Majundar *et al*., 1998). Instead, the studies conducted by Nouri *et al*., (2009) showed that carrot seed extract induces spermatogenesis in male rats. The biochemical mechanism

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underlying the effect is explained by the raised testosterone levels in the male rats, and by the fact that the extracts from carrot seeds are rich in compounds with antioxidant activity.

Being a healthy and nutritious taproot, carrot is very popular and is cultivated around the world. There are in the literature lot of studies focusing on the germplasm resource, breeding, tissue culture, and molecular research of carrots. Future research on carrots may focus on the perspective of molecular biology, with arguments for and against genetic modification of this type of vegetable.

Conclusions

A universal consensus has been established between an equilibrated diet and its preventive role against various diseases. The inhibitory actions of the phytochemicals present in vegetables against major diseases have opened new perspectives to explore their ameliorative properties and reparative characteristics. These polyphenols, flavonoids, and carotenoids available in the carrot have been considered to substantially contribute as a defence against certain ailments including many types of cancer, diabetes mellitus, cardiovascular and oxidative stress. Therefore, these phytochemicals from carrots could be used as a complementary medicine for the prevention and treatment of a number of diseases and disorders, and may be involved in the mitigation of the health impacts of the indiscriminate and unscrupulous use of synthetic drugs especially in the poor and underdeveloped countries. This review clearly demonstrates that carrot and carrot products can provide a wide range of preventive and therapeutic properties against different diseases including different types of neoplasms. However, if a product that contains carrot is to be released to the market, more detailed studies on the health benefits are required to establish the safety and efficacy of the phytochemicals present due to the fact that this type of vegetable has a complex biochemical profile.

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