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Preliminary aspects regarding the antioxidant activity of some unconventional plants for food applications

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Abstract

In the human body, oxidant–antioxidant imbalance impairs cell functions and immunity and promotes cell death and DNA damage, which can cause mutations and ultimately contribute towards the development of chronic diseases such as cancer, this is the most important reason why we are interested in this subject. Recently, there has been growing interest in research into the role of plant-derived antioxidants in food and human health. Antioxidant compounds in food play important roles as health-protecting factors. Antioxidants are also widely used as additives in fats and oils in food processing to prevent delay spoilage of foods. Spices and some herbs have received increased attention as sources of many effective antioxidants. This study focuses on the antioxidant properties of various vegetal species with food applications potential, such as unconventional plants (dandelion and stinging nettle), spice (saffron bulbs) and vegetables (artichoke).

Keywords: antioxidant activity; phenolic compounds; saffron corms; artichoke

1. Introduction

The Antioxidants' are substances that neutralize free radicals or their actions. Nature has endowed each cell with adequate protective mechanisms against any harmful effects of free radicals: superoxide dismutase (SOD), glutathione peroxidase, glutathione reductase, thioredoxin, thiols and disulfide bonding are buffering systems in every cell. α-Tocopherol (vitamin E) is an essential nutrient which functions as a chain-breaking antioxidant which prevents the propagation of free radical reactions in all cell membranes in the human body. Ascorbic acid (vitamin C) is also part of the normal protecting mechanism. There are different attributes to classify the antioxidants. The first attribute is based on the function: They are the chain breaking antioxidants which react with lipid radicals and convert them into more stable products. Antioxidants of this group are mainly phenolic, in structure and include the following: Antioxidant minerals, antioxidant vitamins and phytochemicals which include flavonoides, catechins, carotenoids, β-carotene, lycopene, diterpene of, black pepper, thyme, garlic, cumin and their derivatives [1,2].

The second attribute is based on enzymatic and non-enzymatic antioxidants: These are phenolic compounds that perform the function of capturing free radicals and stopping the chain reactions. The compounds include: Butylated hydroxy anisole (BHA), butylated hydroxy toluene (BHT) and propyl gallate (PG) [3].

In food science, it is defined as a substance in foods when present at low concentration compared to those of an oxidizable substrate significantly decreases or prevents the adverse effects of reactive species such as reactive oxygen and nitrogen species or normal physiological functions in human [4].

Various antioxidants show substantially varying antioxidant effectiveness in different food systems due to different molecular structures. The antioxidant should not impart any off-odor and off-color: it should be able to get conveniently incorporated to food/food systems and should be stable at pH of the food system and during food processing.

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Various factors which affect the efficiency of antioxidants include activation energy of antioxidants, redox potential, stability to pH and processing and solubility [5].

The antioxidant activities of any plants are mainly attributed to their phenolic and flavonoid compounds and she can't be measured directly but rather by the effects of the antioxidant in controlling the extent of oxidation. Methods show extreme diversity [6]. Some methods involve a distinct oxidation step followed by measurement of the outcome as, for example, oxidation of linoleic acid followed by determination of diene conjugation. In other instances, there is no clear distinction between the various steps in the procedure [7].

The phenolic compounds: A class of chemical compounds in organic chemistry which consist of a hydroxyl group (-OH) directly bonded to an aromatic hydrocarbon group is known as phenols or phenolic. The first member of this class is phenol commonly called as carbolic acid. All other members of phenolic family are known as derivatives of phenol. Many phenolic compounds occur in nature and used in manufacturing of perfumes and flavors because of their pleasant odor [8].

Phenolic compounds are basically involving plant metabolic system and widely spread throughout the plant kingdom. Phenolic compounds have potential against oxidative damages diseases; therefore, play a protective role through ingestion of fruits and vegetables. These compounds are very much essential for the growth of plant and involve in reproduction process of plants. These compounds produced during the response process against pathogens for defending injured plants. Because of their antioxidant activities, they widely used in processed foods as a natural antioxidant [9].

Food composition and food additives play major role in providing the required antioxidants for the body. Although of plants and traditionally spices have been used in food preparations to improve the flavor and taste, today they are also frequently used as antioxidant-food supplements. In this context, the study focused on the evaluation of antioxidant activities of extracts obtained from vegetal species with food applications potential, such as unconventional plants (dandelion and stinging nettle), spice (saffron bulbs) and vegetables (artichoke). Literature data reveal a significant relationship between antioxidant capacity and total phenolic content of these vegetal materials [10].

2. Phytochemical properties of the natural extract from the plants

Saffron (*Crocus sativus* L. stigma), the most valuable medicinal product, food belongs to the *Iridaceae* family which has been widely used as a coloring and flavoring agent.

He is a source of plant polyphenols/carotenoids, used as important spice and food colorant in different parts of the world. It has also been used in traditional medicine for treatment of different types of illnesses since ancient times. The stigmas of the saffron flower contain many chemical substances: Carbohydrates, minerals, mucilage, Vitamins (especially riboflavin and thiamine) and pigments including crocin, anthocyanin, carotene, lycopene, flavonoids, amino acids, proteins, starch, gums, and other chemical compounds have also been described in saffron. Characteristic components of saffron are crocin (responsible for the color), picrocrocin- (responsible for the bitter taste), and safranal (responsible for odor and aroma).Saffron contains more than 150 volatile and aroma-yielding compounds [8]. It also has many non-volatile active components, many of which are carotenoids including zeaxanthin, lycopene, and various α- and β-carotenes. The volatiles with a very strong odor are consistent of more than 34 components that are mainly terpenes, terpene alcohols, and their esters. Non-volatiles include crocin 14 that are responsible for the red or reddish-brown color of stigmas together with carotenes, crocetin, picrocrocin (a glycosidic precursor of safranal), the bitter substance and safranal the major organoleptic principle of stigmas. However, saffron's golden yellow-orange color is primarily due to α-crocin. This crocin is *trans*-crocetin di-(β-d-gentiobiosyl) ester. Systematic (IUPAC) name: 8, 8-diapo-8, 8-carotenoic acid. This means that the crocin underlying saffron's aroma is a digentiobiose ester of the carotenoid crocetin. Crocin themselves are a series of hydrophilic carotenoids that are either mono-glycosyl or di-glycosyl polyene esters of crocetin. Meanwhile crocetin is a conjugated polyene dicarboxylic acid that is hydrophobic and thus oil soluble. When crocetin is esterified with two water-soluble gentiobioses (which are sugars), a result that is itself water soluble. The resultant α-crocin is a carotenoid pigment that may comprise more than 10% of dry saffron's mass. The two esterified gentiobioses make α-crocin ideal for coloring water based (nonfatty) foods such as rice dishes. A hypothetical protocrocin of the fresh plant is decomposed on drying into one molecule of crocin and two molecules of picrocrocin. Crocin on hydrolysis yields gentiobiose and crocetin, while picrocrocin yields glucose and safranal. The bitter glucoside picrocrocin is responsible for saffron's flavor. Picrocrocin (chemical formula: $C_{16}H_{26}O_7$, systematic name: 4-(β-d-glucopyranosyloxy)-2, 6.6-trimethylcyclohex-1-ene-1-carboxaldehyde) is a union of an aldehyde subelement known as safranal (systematic name: 2, 6, 6-trimethylcyclohexa-1, 3-dien-1-carboxaldehyde) and a carbohydrate. It has insecticidal and pesticidal properties and may comprise upto 4% of dry saffron. Safranal is less bitter than picrocrocin and may comprise up to 70% of dry saffron's volatile fraction in some samples.

A second element underlying saffron's aroma is 2-hydroxy-4, 4, 6-trimethyl-2, 5-cyclohexa-dien-1-one, the scent which has been described as "saffron, dried hay-like." Callus cultures at ρH: 7.0-7.6 with added uridine-diphosphoglucose are able to transform all *trans*-crocetin into its related glycosides. An antioxidant 3, 8-dihydroxy-1-methylanthroquinone-2-carboxylic, claimed to be superior to vitamin E in its inhibition of oxidation of linoleic acid, has been isolated from callus stem tissue of saffron. Dry saffron is highly sensitive to fluctuating pH levels and rapidly breaks down chemically in the presence of light and oxidizing agent. It must, therefore, be stored in air-tight containers in order to minimize contact with atmospheric oxygen. *C. sativus* has been shown to have anti-depressant effects, two active ingredients are crocin and safranal [11].

Saffron has a long history of use as a spice and for its wonderful color, odor and taste. During the recent years public interest towards using natural additives instead of synthetic chemicals has led to a breakthrough in using saffron ass a natural flavoring in food industries. Today saffron is widely used in confectionary, alcoholic and non-alcoholic beverages and its use as a coloring agent for sausages, oleomargarines and shortening is allowed in USA [11].

Artichoke (*Cynara scholium's* L.) is an herbaceous perennial plant native to the Mediterranean Basin that belongs to the Asteraceae family. Consumed raw, boiled, steamed or fried, this plant is today widely cultivated all over the world for its large fleshy immature inflorescences, called heads or capitula, with edible leaves (bracts) and receptacle. Artichoke is known since ancient times as a tasty plant that can be used in soups, stews and salads, being perceived as a nutritious and healthy vegetable due to its antioxidant and hepatoprotective effects The Globe artichoke is considered a healthy food due to its nutritional and phytochemical composition. It contains proteins, minerals, a low amount of lipids, dietary fiber and a high proportion of phenolic. The phenolic include cynarin (1,3-di-O-caffeoylquinic acid) (figure5), luteolin, cynaroside (luteolin-7-O-glucoside), scolymoside (luteolin-7-rutinoside); phenolic acids such as caffeic, coumaric, hydroxycinnamic, ferulic, caffeoylquinic acid derivatives; mono- and dicaffeoylquinic acids, including chlorogenic; acid alcohols; flavonoid glycosides, among others [12].

The Dandelion (*Taraxacum officinale*, Weber, *T. Densleonis*, Desf; *Leontodon taraxacum*, Linn.), though not occurring in the Southern Hemisphere, is at home in all parts of the north temperate zone, in pastures, meadows and on waste ground, and is so plentiful that farmers everywhere find it a troublesome weed, for though its flowers are more conspicuous in the earlier months of the summer, it may be found in bloom, and consequently also prolifically dispersing its seeds, almost throughout the year.

From its thick tap root, dark brown, almost black on the outside though white and milky within, the long-jagged leaves rise directly, radiating from it to form a rosette Iying close upon the ground, each leaf being grooved and constructed so that all the rain falling on it is conducted straight to the centre of the rosette and thus to the root which is, therefore, always kept well-watered. The maximum amount of water is in this manner directed towards the proper region for utilization by the root, which but for this arrangement would not obtain sufficient moisture, the leaves being spread too close to the ground for the water to penetrate.

The leaves are shiny and without hairs, the margin of each leaf cut into great jagged teeth, either upright or pointing somewhat backwards, and these teeth are themselves cut here and there into lesser teeth. It is this somewhat fanciful resemblance to the canine teeth of a lion that (it is generally assumed) gives the plant its most familiar name of Dandelion, which is a corruption of the French *Dent de Lion*, an equivalent of this name being found not only in its former specific Latin name *Dens leonis* and in the Greek name for the genus to which Linnaeus assigned it, *Leontodon*, but also in nearly all the languages of Europe.

Dandelion is a source of various nutrients and biologically active substances and its root and leaves contain vitamins (A, K, C and B-complex), minerals (calcium, magnesium, potassium, zinc and iron), micronutrients, fibre, lecithin and choline. The various parts of the plant have a long history of use as an herbal remedy; roots of this herb are firstly considered for enhancing digestion. Also, the roots are generally used for as liver tonic by stimulating bile production and removing toxins and re-establishing hydration and electrolyte balance. Dandelion leaves could be used successfully as digestive stimulant and diuretic. Moreover, dandelion leaves were reported to improve growth and productive performance of poultry. Several beneficial effects have been reported on intestinal mucosa regarding architecture of villi, villus height/ crypt depth ratio as well as cellular infiltration. Dandelion has many properties like immunomodulatory, digestive stimulant, prebiotic, insulin stimulant, anti-inflammation, antiangiogenic, antineoplastic and demulcent. Furthermore, dandelion treats indigestion and hepatitis B infection as well as enhances metabolise androgenic hormones.

The chief constituents of Dandelion root are Taraxacin, acrystalline, bitter substance, of which the yield varies in roots collected at different seasons, and Taraxacerin, an acrid resin, with Inulin (a sort of sugar which replaces starch in many of the Dandelion family, *Compositae*), gluten, gum and potash.

The root contains no starch, but early in the year contains much uncrystallizable sugar and laevulin, which differs from Inulin in being soluble in cold water.

Thisdiminishes in quantity during the summer and becomes Inulin in the autumn. The root may contain as much as 24 per cent. In the fresh root, the Inulin is present in the cell-sap, but in the dry root it occurs as an amorphodus, transparent solid, which is only slightly soluble in cold water, but soluble in hot water.

There is a difference of opinion as to the best time for collecting the roots. The British Pharmacopceia considers the autumn dug root more bitter than the spring root, and that as it contains about 25 per cent insoluble Inulin, it is to be preferred on this account to the spring root, and it is, therefore, directed that in England the root should be collected between September and February, it being considered to be in perfection for Extract making in the month of November [13].

Stinging nettle (*Urtica dioica*) is a large, rhizomatous perennial wild edible plant that can grow quite tall. Originally from Europe and Asia, this plant has sharp hairs that break easily and can irritate or sting when the plant is touched; however, it is a vi0tamin-rich food source as well as a remedy for various medical conditions. Stinging nettle has been used for hundreds of years to treat painful muscles and joints, eczema, arthritis, gout, and anemia. Fibrous stems of mature plants can be used to make twine, fishing nets, snares and other items. Nettles were traditionally dried and fed to livestock throughout winter. Previously conducted study, regarding chemical composition, showed that SN leaves contain biologically significant classes of chemical compounds. Analysis revealed that leaves contain terpenoids as the main component of essential oil, carotenoids including b-carotene, neoxanthin, violaxanthin, lutein and lycopene, fatty acids, especially palmitic, cis-9,12 linoleic and α-linolenic acids, different polyphenolic compounds, essential amino acids, chlorophyll, vitamin C, vitamin K, vitamins B series, tannins, carbohydrates, sterols, polysaccharides, isolectins and minerals of which the most important is iron. This plant has a long history of application as a food in many countries. It has been used as a vegetable in Mediterranean countries, for preparation of many dishes such as soups, rice dishes, in combination with noodles, omelets or scrambled eggs or as a salad [14,15].

3. Phenolic compounds and antioxidant activity

Saffron corms. Many studies on medicinal properties of saffron have indicated that saffron has a potent antioxidant activity which is mostly due to the presence of crocin as a unique carotenoid. The crocin bleaching assay was also designed according to this important property of crocin as a basic element for the antioxidant activity of saffron.

It was shown that the antioxidant properties of methanol and water-methanol (50:50 v/v) extract of *Crocus sativus* stigmas were higher than those of tomatoes and carrots.

The antioxidant activity was overall lower in saffron components than Trolox and BHT, especially safranal, but crocetin was closer to BHT and Trolox. The antioxidant activity of dimethylcrocetin was concentration dependent, with a peak in 40 μg/mL. However, the synergistic effect of all the bioactive constituents gave saffron a significant antioxidant activity. The antioxidant property of crocin was evaluated in comparable amounts with butylated hydroxy anisole (BHA). Crocin showed a high radical scavenging activity (50% and 65% for 500 and 1000 ppm solution in methanol, respectively), followed by safranal (34% for 500 ppm solution). High radical scavenging activity of these compounds is probably due to their ability to donate a hydrogen atom to the DPPH radical [16].

Artichoke. Artichokes exhibit a high antioxidant capacity placed it as number 17 in the ranking of the 50 foods with the highest antioxidant content, reaching the fourth place when the antioxidant content is expressed in terms of the serving size [17,18].

The content of phenolic varies among different cultivars, age, generation of the plant, growing conditions, harvest, post-harvest and storage conditions, and the technological procedures used. In addition, artichoke leaf extracts have long been used in folk medicine, particularly for liver complaints. These therapeutic properties have been often being ascribed to the cynarin (1, 3-O-dicaffeoylquinic acid) content of these extracts. In various pharmacological test systems, artichoke leaf extracts have exhibited hepatoprotective, anticarcinogenic, antioxidative, antibacterial, anti-HIV, bile-expelling, and urinative activities as well as the ability to inhibit cholesterol biosynthesis and LDL oxidation. These broad therapeutic indications cannot be ascribed to a single, but to several active compounds that together generate additive or synergistic pharmacologic effects; these include mono- and dicaffeoylquinic acids, and flavonoids such as luteolin and its 7-O-glucoside. Artichoke by-products such as leaves, external bracts and stems that are produced by the artichoke processing industry, represent a huge amount of discarded material (about 80–85% of the total biomass of the plant), which could be used as a source of inulin but also of phenolic, and should be considered as a raw material for the production of food additives and nutraceuticals [19].

Dandelion. Despite the limited number of recent studies into the antioxidant activities of extracts from dandelion root, there is reasonable evidence to support the use of dandelion tissues as natural sources of antioxidants, largely due to the presence of phenolic compounds.

Detailed knowledge of the identity and quantity of the compounds responsible for the antioxidant activity of dandelion plants is essential if they are to be exploited as a source of compounds with the ability to alleviate the oxidative stress associated with some diseases.

However, to date investigations into the antioxidant activity and phenolic content of dandelion have principally concentrated on the aerial parts and often only the evaluation of single crude extracts. For example, chromatographic analysis of a dandelion flower ethyl acetate fraction revealed the presence of luteolin, luteolin-7-O-glycoside, caffeic acid and chlorogenic acid, while the luteolin, chicoric and total phenolic content leaf extracts has also been measured spectrophotometrically. In the root itself, the presence of phenolic compounds such as chicoric acid, chlorogenic acid and monocaffeyltartaric acid have been reported from commercial root coffee and capsules [20].

4. Conclusion

Food ingredients with antioxidant properties are important component for food industry. In the past, antioxidants were used primarily to control oxidation and retard spoilage, but today many of those are used because of their putative health benefits. However, the traditional message that oxidative stress, which involves the production of reactive oxygen species (ROS), is the basis for chronic diseases and aging is being reexamined. Accumulating evidence suggests that ROS exert essential metabolic functions and that removal of too many ROS can upset cell signaling pathways and actually increase the risk of chronic disease. It is imperative that the food industry be aware of progress in this field to present the science relative to foods in a forthright and clear manner. This may mean reexamining the health implications of adding large amounts of antioxidants to foods. Nowadays, there is a continuous concern regarding the identification and valorization in food application of underused vegetal species with antioxidant potential. The reviewed studies prove that investigated plants show antioxidant properties and are suitable to be used as food ingredients in many ways.

Compliance with Ethics Requirements. Authors declare that they respect the journal's ethics requirements. Authors declare that they have no conflict of interest and all procedures involving human / or animal subjects (if exist) respect the specific regulation and standards.

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