

CITRUS AS A COMPONENT OF THE MEDITERRANEAN DIET

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ABSTRACT

Citrus are native to southeastern Asia, but are present in the Mediterranean basin for centuries. This group of species has reached great importance in some of the Mediterranean countries and, in the case of orange, mandarin and lemon trees, they found here soil and climatic conditions which allows them to achieve a high level of fruit quality, even better than in the regions where they came from. Citrus fruits are present in the diet of the peoples living on the Mediterranean basin, at least since the time of the Roman Empire. In the 20th century they became the main crop in various agricultural areas of the Mediterranean, playing an important role in the landscape, in the diet of the overall population, and also in international trade. They are present in the gardens of palaces and monasteries, but also in the courtyards and orchards of the poorest families. Their fruits are not only a refreshing dessert, but also a condiment, or even a major component of many dishes. Citrus fruits have well-documented nutritional and health benefits. They can actually help prevent and cure some diseases and, above all, they are essential in a balanced and tasty diet.

Keywords: Orange, Mandarin, Clementine, Ascorbic Acid.

JEL Classification: Q10.

1. INTRODUCTION

Citrus are native to subtropical and tropical regions of Asia and the Malay Archipelago (Vavilov, 1926), but are present in the Mediterranean basin for centuries. This group of species has reached great importance in some of the Mediterranean countries and, in the case of orange, mandarin and lemon trees, they found in these regions, soil and climatic conditions which allows them to produce superior fruit quality. The hot summers and the mild winters, but with some alternation of low and high temperatures, make the fruits have a more attractive flavor and color than the fruits produced in the areas with warmer climates, where the citrus species had their origin.

Citrus fruits are present in the diet of the peoples living on the Mediterranean region for many centuries. The Roman agronomists already made many references to the cultivation of citrus fruits within the limits of their empire. Citrus fruits are not only consumed as a refreshing dessert, they are also used as a condiment, or even as a major component of many

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dishes, like roasted duck with orange or pork tenderloin with blood oranges. Citrus fruits have well-documented nutritional and health benefits, mainly attributed to high levels of bioactive compounds (Duarte *et al.*, 2016), such as phenols, including flavonoids, limonoids, essential oils and vitamins, particularly the vitamin C (Miguel *et al.*, 2009; Duarte *et al.*, 2010), and carotenoids. They can actually help to prevent some diseases and, above all, they are essential in a balanced and tasty diet.

Although citrus fruits were apparently unknown in the Mediterranean basin in ancient times, in Greek mythology it is possible to find multiple references to the mythical “golden apples”, which may well have been based upon oranges or citrons. With the introduction of good sweet orange cultivars, citrus started to play an important role in the landscape. In the 20th century, innovation in water pumping and irrigation methods, along with other factors, caused the citrus became the main crop in various agricultural areas of the Mediterranean, playing an important role in the landscape, and also in international trade. Citrus trees are present in the streets of many cities, in the gardens of palaces and monasteries (Figure 1), but also in the courtyards and orchards.

Figure 1 - Court of Oranges in the Great Mosque of Cordoba (Spain)



In this article, based on a literature review we intend to describe the importance of the citrus as a component of the Mediterranean diet. The origin of the species and its sprawling around the Mediterranean basin landscapes, along with its importance for healthy diets, are the main topics explored.

2. THE ORIGIN OF CITRUS AND ITS INTRODUCTION IN MEDITERRANEAN AREA

2.1 Citrus taxonomy

Edible citrus fruits exhibit huge diversity of shapes, colors and flavors and its classification is extremely difficult (Figure 2).

Oranges, mandarins, lemons, limes, grapefruits, pummelos, citrons and other citrus are classified in the botanical genus *Citrus* and can be distributed over more than one hundred species (Tanaka, 1954, 1961) or just on sixteen species of citrus (Swingle, 1943, 1967). Recently it was proposed a new classification of citrus, in which the genera *Poncirus*, *Fortunella* and *Eremocitrus* are included in the genus *Citrus* (Mabberley, 2008). This difficulty in classifying the citrus fruit is due to the facility with which almost all of them may cross each other, giving rise to new interspecific or intergeneric hybrids and is also associated with the frequent occurrence of mutations which give rise to plants with minor or major changes in relation to the mother plant. In fact, there are three true species of edible citrus, which gave rise to numerous hybrids and mutants that are grown throughout the world. These true species are the citron (*Citrus medica*), the mandarin (*Citrus reticulata*) and the pummelo (*Citrus maxima*) (Mabberley, 1997; Scora, 1975, 1988).

Figure 2 - Diversity of citrus fruits produced in the Mediterranean basin. In the photograph we can see grapefruit (pigmented and non-pigmented), lemons, limes, blood oranges and mandarins



The orange, mandarin and lemon trees grown in the Mediterranean countries are hybrids among these ancient citrus species. Actually, mandarin is the name of a citrus group whose fruits are smaller, easier to peel and of flattened shape, when compared with oranges. The trees are usually smaller, and leaves are smaller and narrower than the orange ones. They can be grouped into a single (*C. reticulata*) species (Mabberley, 1997, 2008), or divided into multiple species (Tanaka, 1954). For this author the mandarins are divided in many species, some of them, cultivated in the Mediterranean (*C. clementina*, *C. unshiu*, *C. deliciosa*, etc.). Many of mandarin varieties are hybrids between some of these species and in some cases, are hybrids of mandarin with orange or grapefruit.

2.2 Origin of the most important citrus species

Native to southeastern Asia, citrus fruits are present in the Mediterranean basin for centuries. As far as we know, the first to arrive was the citron, then the sour orange and the lemon tree, followed by sweet orange, and finally, the mandarin.

Citron

The citron is native to India and has been cultivated in Asia since ancient times. The Greeks must have known it on the occasion of the invasions of Alexander the Great, and because they had found it in the Persia (Media), they knew it as “Median fruit” according to Theophrastus in *Historia Plantarum*. And it was the Greek name that caused Linus to give this species the name *Citrus medica*. Citron was the first citrus fruit to be introduced into the Mediterranean basin. A variety of citron is used by Jewish people in the feast of tabernacles (Figure 3).

Figure 3 - ‘Etrog’ citron (*Citrus medica* L.) used by Jewish people in the feast of tabernacles



Due to some similarity of the fruit and difficulties of translation between ancient and modern languages, sometimes what is known as lemon (*Citrus limon*) and what we know as citron (*Citrus medica*) is sometimes confused.

The lemon possibly came to the Mediterranean only under arabic influence at the 8th century but the citron was certainly present in antiquity (Pagnoux *et al.* 2013). At least the citron was known to the Greeks and Romans, which ate and attributed to the fruits and leaves pharmacological properties (Wilkins & Hill, 2015). Its presence is attested, for example, on the prices edict of Diocletian on 301 A.D. In this *Edictum De Pretiis* the citron is referred as “Citrium maximum” and costs 24 Denarii per each of the largest size, while 24 figs were 4 Denarii (Edict. Diocl. 6, 75). It was therefore an expensive product and not accessible to everyone. The discovery of some seeds of a citrus fruit of the *Citrus medica* in Pompeii in contexts of the 1st and 2nd century BC seems an evidence for the importing of this products from a long distance (Pagnoux *et al.*, 2013). The other members of citrus, such as lemon, or orange (bitter orange) were not known in the Mediterranean until the Post-Classical period (Wilkins and Hill, 2006).

Citron was grown for fruit production during several centuries and later as rootstock for other citrus fruits. In Portugal, this use of the citron as rootstock lasted at least until the end of the 18th century (Garrido, 1789).

Mandarins

The mandarin (*Citrus reticulata*) probably originated in the Southeast China or Indochina, and was cultivated in that area for many centuries (Verheij and Coronel, 1992).

Although known in the East from ancient times, it only arrived in Europe in 1805, on an import from China to England. In this country it was cultivated as ornamental, in greenhouses (orangeries). From England mandarin was taken to Malta and then to Sicily and to continental Italy. In Spain, mandarin was introduced in 1845 but its cultivation began in 1856, in the province of Castellón (Zaragoza, 1991).

It is not known for sure which one was the first mandarin that arrived in the Mediterranean, but probably it will have been that which was later called “Mediterranean mandarin” or “common mandarin”. The trees of the species produce those which are perhaps the tastiest of all citrus fruits. That’s why, its scientific name is *Citrus deliciosa*, which means, delicious citrus. The area of cultivation of this species has been decreasing because of the perishability of the fruits and the tendency for an alternating production with years of low production and years of excessive tree load. Even so, some varieties of this species (‘Avana’ group in Italy and ‘Setubalense’ in Portugal) still have a significant production. Besides the sweetness of the fruits, they are distinguished by the extraordinary aroma of the fruits and leaves.

One of mandarin species most cultivated in the Western Hemisphere originated in the Mediterranean. We refer to the clementine (*C. ×clementina*). This species came to exist as a result of accidental hybridization between a mandarin and a sweet orange (Barkley, 2006; Wu *et al.*, 2014). The first fruits were discovered by Brother Clément Rodier (after whom the fruit was named in 1902 in French and then in other languages) in the garden of his orphanage in Misserghin, near to Orán, Algeria. However, there are claims it is nearly identical to the Canton mandarin widely grown in the Guangxi and Guangdong provinces in China (Chapot, 1963). In any case, it was in the Mediterranean basin that the cultivation of clementines was perfected and it was here that new varieties of this group appeared. The seedless clementines are one of the most commercialized fruits in Europe.

Pummelo

According to Vavilov (1926), the pummelo (*C. maxima* Burm. Merrill) originates from the Indo-Malayan Center of origin of cultivated plants, which includes Indo-China and the Malay Archipelago. This species is little cultivated in the western hemisphere, but its

importance is due to the fact that it is one of the progenitors of the orange and grapefruit species (Velasco and Licciardello, 2014). It produces the largest citrus fruits (Figure 4).

Figure 4 - Pummelo in a citrus collection in Algarve



Orange

Orange is a relatively heterogeneous group of citrus, including trees which produce medium-sized fruits, round to slightly oval in shape and whose rind separates with difficulty from the pulp. All oranges are hybrids of ancient cultivated origin, possibly between pummelo (*Citrus maxima*) and mandarin (*Citrus reticulata*). In this group we include sour orange (*Citrus aurantium*) and sweet orange (*Citrus sinensis*). The origin of sweet orange is not known with certainty. It is thought to be southern China, CochinChina, Burma and regions of India, south of the Himalayas (Reuther *et al.*, 1967).

Sweet orange was widely cultivated in China, before being known in Europe. The culture had reached a fairly high degree of perfection at those times. The earliest known reference to sweet orange is found in the book “Yu Kung” dedicated to Emperor Ta Yu (2205-2197 BC). The oldest work dedicated to the cultivation of citrus fruits is the book entitled “Kiu lu” (or “Chü lu”), written by Han Yen-chih in Wenchou, in 1178. It is a complete work in which 27 varieties (of sweet and sour orange, mandarin, citron, kumquat, trifoliolate, etc) are described. Among the varieties described, there are seedless sweet oranges. In this book, cultural techniques such as pruning, grafting, applying manure, treating pests, harvesting the fruits and their different uses are described.

What is the path followed by sweet orange to reach Europe, is an issue that has not yet been clarified. According to Gallesio (1811), between the X and XV centuries there is no reference to the presence of sweet orange in Europe. It seems that the species was not cultivated in Europe until the middle of the 15th century. From the early sixteenth century there are abundant references indicating that sweet orange is not only known, but is widely cultivated in southern Europe.

Some facts point to the possibility that, it was the Portuguese who imported the sweet orange tree from China, after discovering the sea route to India and having reached the shores of southern China. Valmont de Bomare in his “Dictionnaire raisonné universel d’histoire naturelle” (1764) says that the first imported sweet orange from which all the sweet orange trees of Europe descended, was grown in the garden of the Count of São Lourenço. The import of this orange tree is attributed to João de Castro and will have been realized, according to some, in 1520, according to others, in 1548. However, the fact that sweet oranges did not surprise the Portuguese navigators who arrived in the East seems to indicate that they already knew this species or at least some edible sour orange cultivars. When Vasco da Gama arrived in Mombasa in 1498, the chroniclers registered the presence of ‘very sweet oranges, much sweeter than those from Portugal’ (Herculano 1861). But this theory is not consensual and other authors report the importation of the first orange tree as occurring later, in 1624 or 1635, by order of Francisco Mascarenhas, governor of Macao (Ferrão, 1963). It may be that sweet orange already existed in Europe and the Portuguese only brought in sweeter varieties. What is indisputable is that the Portuguese played an important role in the expansion of orange culture in Europe, where in many countries the word orange is very similar to the word Portugal, as in the American continent, since it was the Portuguese who introduced the orange and other citrus fruits in Brazil (Ferrão, 1992).

The orange tree was introduced in the Algarve (south of Portugal) around the year 1635. In the middle of the 18th century, the Algarve already had an important orange production, even making some exports of this and other citrus fruits (sour orange and lemon) (Magalhães, 1988).

Lemon

The origin of the lemon tree is not well determined. It is thought to be South-East Asia, South China or Burma. No Chinese reference to this plant is known until the 12th century of our era. Only in 1175 did Fan Ch’eng-ta describe the fruit with the name “li-mung.” It seems strange, due to the proximity of the center of origin, that the Chinese did not know this tree. In the book about the orange Kiu lu, there is no mention of lemon. More recent data point to the possibility that lemon was already known in China 500 years before Christ (Mansfield, 2006). In India, it has been known in recent times and no wild lemon trees have been found. In the 10th century, the Arab geographers Istakhri and Ibn Haukal referred to an Indian fruit called “limunach”. Everything seems to indicate that lemon tree originated later than citron and sour orange, by mutation or hybridization among other citrus fruits (one of which would be citron). Some studies seem to support this hypothesis (Malik *et al.*, 1974).

The mosaics of Pompeii, the reference to lemon in the *De Re Coquinaria*, the best-known cookbook of the Romans (Apicius, 1936) and other similar references could indicate that there were already lemon trees there in the times of the Roman Empire. However, it is more likely that there were intermediate forms between the citron and the lemon, or some kind of lemon different from the one we know today in Europe. The confusion is compounded by the fact that lemon has often been mistaken for citron and also because the term “lemon” groups other forms of citrus fruit (limes, and others) although some are quite distinct from our lemon.

In any case, it seems that it was the Arabs who spread the lemon tree along the shores of the Mediterranean along with the sour orange tree, or possibly a little later. It is assumed that the lemon tree arrived in Spain about the year 1150. Abu-Zaccaria’s book seems to indicate that lemon, sour orange and citron were already known and grown in the area of Seville.

Also the crusaders could have brought lemon trees to Europe. Jacques de Vitry, bishop of St. John of Acre (Palestine) in the 13th century, in his “History of Jerusalem” describes the abundant presence of cider, sour orange and lemon trees in Syria and Palestine. According to him, these fruits were not very common in Europe.

3. CITRUS IN THE MEDITERRANEAN LANDSCAPES

Mediterranean region have a great ecological diversity, as well as a great cultural diversity due to its long human history. Both, together, gave their contributions for the great richness of Mediterranean landscapes, but it is generally agreed that the Mediterranean region natural resources and landscapes had suffered one of the strongest pressures or depletions due to man’s misuse (Naveh & Dan, 1973).

Citrus trees could be very appealing landscape elements, from the observer perspective, due to their compact canopies with bright evergreen green leaves. During blossom their flowers imprint a sweet scented into the air around and during fruitification, the orange colored “balls” around the contrast with the green in such a harmonious way, that even a single tree could be seen as an ornamental element of the space (Figure 5). Although citrus trees were apparently unknown in the Mediterranean basin in ancient times, in Greek mythology we find multiple references to the golden apples, particularly in the garden of the Hesperides located somewhere between the Italian Peninsula and the Iberian Peninsula.

Figure 5 - Navel orange tree growing in the Algarve (Portugal) showing its “golden apples”



These mythical golden apples may well have been based upon oranges or citrons, which the Greeks may have been aware of because of their trade with the East. The citrus fruit, a modified berry with a thick rind and multiple seeds, was called hesperidium”, alluding to those mythical “golden apples” of the Greek goddesses Hesperides. After the discovery of

the sea route to India and China, and the introduction of good sweet orange cultivars, citrus started to play an increasing role in the diet of the overall population, in international trade, and, of course, in the landscape.

For centuries, these lemon or orange trees, of an intense green with abundant golden fruits, have become part of the landscape of the Mediterranean basin. Citrus trees have been present in the gardens of palaces and monasteries, in the streets of Mediterranean cities, and in the courtyards and orchards of the poorest families. Because citrus trees are high water (and nutrients) consumption plants, until the mid-twentieth century the citrus trees were located in the most fertile plains and also in the valleys of the mountainous areas. In rare cases, they were planted in some sloppy areas where it was possible to bring water through ingenious irrigation canal systems. And, for this reasons, until the 1950's, citrus trees had a discrete presence in the Mediterranean rural landscapes.

The development of technologies capable of drilling the ground up to hundreds of meters deep and placing submerged pumps there, has led to an increase in the availability of water for irrigation. In addition, the transport of irrigation water by pipes, instead of canals, allowed irrigation of land where previously only drought tolerant crops could grow. This allowed also the citrus trees to climb the slopes and settle in areas they could not dream of before (Figure 6). Along with human population increase, these technological innovations have made citrus fruit the most important crop in various agricultural areas of the Mediterranean and worldwide.

Figure 6 - Citrus orchard on a hillside where formerly almond, carob, fig and olive trees were grown. The installation of this orchard was only possible with strong water pumping and drip irrigation



From an economic point of view citrus production is estimated above 130 million tons per year (FAO, 2016), meaning that rank first in terms of world fruit production and international trade value. Citrus fruits are cultivated in many countries around the world. The main citrus fruit-producing countries are Brazil, China, the United States and

the Mediterranean region; representing more than two thirds of the global citrus fruit production. According to CLAM⁵ data, the Mediterranean Basin accounts for about 20% of the world citrus production (and about 60% of the world fresh citrus trade). The production is mainly composed of sweet oranges and mandarins-like fruits. Citrus is a major segment in the Mediterranean agricultural industry with citriculture representing a major source of income to a significant number of people. It is a source of employment at various levels of the chain, mainly during production because most of the fruit is harvested by hand, and play a role as a driving force to the economy of the entire Mediterranean region.

In the Mediterranean basin, Spain is the leading producing country, whereas Italy and Egypt rank second and third, respectively. According to Eurostat Statistics Explained (data from 2007), the European countries (UE 28) with the largest area under citrus tree fruits orchards are Spain, followed by Italy, Greece, Portugal, France and Cyprus. In specific geographic areas, such as in the Algarve, Andalucía, Valencia region, Corsica, Sicily, citrus are the main or one of the main fruit crops.

In the Mediterranean countries, citrus farm size varies from less than one hectare to a few hundred hectares. Farms larger than 10 ha account for 80% of the production and are usually technologically advanced (Lacirignola & D'Onghia, 2009). Due to that, on those areas of the Mediterranean region, presently citrus orchards commonly dominate the rural landscapes, imprinting on them their very homogeneous regular pattern of equally distributed similar intense green and perfectly shaped canopy trees spread all over an entire huge patch or an entire landscape. In the opinion of Aranzabal, Schmitz, Aguilera and Pineda (2008), the cultural rural landscape of the Mediterranean basin has undergone notable changes in the last few decades. They considered that rural abandonment, on one hand, and on the other, agricultural intensification, are creating a new type of rural landscape which spatial configuration is apparently less appealing than the traditional one (Figure 7).

Figure 7 - Small citrus orchards surrounded by abandoned traditional dryland orchards,



Spatial heterogeneity, depending upon a balanced proportion of the agricultural croplands, pasture and woodland patches, seems to make part of an appraisal rural landscape, say the authors. And we add that those features certainly not correspond to a landscape extensively dominated by citrus orchards. The very pleasant feeling associated with the presence of

⁵ CLAM -Comité de Liaison de L'agrumiculture Méditerranéenne

a citrus tree or a few ones around, and the nice ever green imprint that a small-medium size orchard patch gives to a rural landscape, in the cases of citrus dominated landscapes is dissolved into the non-ending repetition of such beautiful trees, equally apart from each other, all over the space that one's eyes could reach.

The simplification on the structure and pattern of the landscape due to extensive citrus orchards, have other consequences below the reduction of landscape diversity and perceived beauty. The reduction of habitats diversity and consequent loss of biodiversity (reduction on species richness and abundance) has been associated with monoculture in rural landscapes. In the case of citrus based landscapes in the Mediterranean, for example Cerdá, Palacios and Retana (2009) analyzed the structure and composition of ant communities in citrus orchards in Catalonia (northeast Spain) and compares them with the ant fauna found in natural communities of the region. They found that the composition of ant communities present in the citrus orchards was extremely poor, with species richness and diversity lower compared with natural communities.

The intensive use of water and fertilizer required by citrus crops have another sidewalk effect – the pollution of aquifers and eutrophication of surface water bodies. Citrus fruits needs usually more natural resources than the crops they have come to replace. Demanding irrigation and fertilization have leads to an increasing importance of intensive agriculture as a source of non-point pollution. Due to its importance in terms of land use in some parts of the Mediterranean, citrus orchards and citrus production could be considered one of the main sources of resources depletion – water use in huge amounts and water contamination with fertilizers and pesticides. The importance of water contamination by intensive agriculture is regulated by EU environmental and agricultural regulations, in order to promote the mitigation of this negative aspect.

For perhaps more than two millennia, citrus trees have been present in many gardens around the Mediterranean, for their perfume, their fruit and their evergreen architectural effect (Handsombe, 2013). Its pleasant and discrete presence at Mediterranean landscapes changed to an almost omnipresence in some landscapes of countries such as Spain or Italy, where huge parts of the territory have a single use – citrus-based orchards - and seems to be covered by a very long mantle made by a very simple repetitive pattern – regular square pattern with one similar tree in each node.

4. USES OF CITRUS IN MEDITERRANEAN COUNTRIES

Citrus beauty and utility are essential to the life of Mediterranean populations. About orange, it is said, in several Mediterranean countries, that it is “gold in the morning, silver at noon, and kills you at night”. The origin of this proverb is not well known, but it is possible that it was invented so that at night people would not steal oranges to eat. It may still be related to a certain difficulty in digestion when eaten after a meal. Either way, the orange is a good food at any time of the day. Oranges and mandarins are mostly used as fresh fruit, for dessert or snacks between meals (Figure 8). Orange juice is often the first morning food. But the orange is very used for seasoning of several dishes, although for that purpose, the most used is the lemon. And in the end of any Mediterranean meal, an orange roll cake or a lemon infusion is always good.

Figure 8 - Peeled fresh orange and orange roll cake



Citrus fruits are also widely used for the production of essential oils and for the manufacture of liqueurs. One of the best known liqueurs is Cointreau, made from a combination of sweet and bitter orange peels, macerated in neutral alcohol and distilled three times to concentrate the flavours. This drink invented by the brothers Adolphe and Edouard-Jean Cointreau has been manufactured since 1849 in the French city of Angers. In addition to this, many are the lesser known liqueurs, manufactured in the Mediterranean countries, from orange, lemon and mandarin fruits.

Among the essential oils produced from citrus, the neroli, made from bitter orange blossoms, is widely known. The name “neroli” was attributed to this essential oil because it was the princess of Nerola, Anne Marie Orsini who began to use it at the end of the 17 century, to perfume the gloves and the bath. Today, there are many perfumes, manufactured based on neroli or other essential oils from citrus.

5. CITRUS AND HEALTH

Citrus fruits have well-documented nutritional and health benefits. Since ancient times that citrus has been used not only as food but also in folk medicine to treat some complaints: bronchitis, tuberculosis, cough, cold, menstrual disorder, hypertension, anxiety, depression and stress (Favela-Hernández *et al.*, 2016). They can actually help preventing and curing some diseases and, above all, they are essential in a balanced and tasty diet. Citrus fruits do not possess sodium, fat and cholesterol, but are sources of several minerals (potassium, calcium, phosphorus, magnesium, copper), vitamins (C, B1, B2, B3, B5, B6, B9), dietary fiber and secondary phytochemicals (carotenoids, phenols, including flavonoids, coumarins, limonoids, alkaloids and essential oils) which alone or in combination have been referred as being able to prevent inflammation, degenerative diseases, heart disease and even cancer (Ejaz *et al.*, 2006; Lv *et al.*, 2015).

Potassium not only helps to maintain the body’s water, acid balance and normal pressure, but also is important in transmitting nerve impulses to muscles as well as in the muscle contraction (Economos & Clay, 1999). Vitamin C plays a key role in the absorption of inorganic iron; which can aid in the treatment of anaemia provided that adequate medicines are also administered. This vitamin is also important in the formation of collagen. A deficiency of this vitamin is responsible for the weakness of those tissues in which collagen is an essential element (ligaments, tendons, dentin, skin, blood vessels and bones). Vitamin B₁ or thiamine is important in the metabolism of carbohydrates and branched-chain amino

acids and is only obtained through food, since humans are not able to produce it. Vitamin B₂ or riboflavin is involved in the oxidation-reduction reactions of metabolic pathways as well as in the respiratory chain for producing energy. Vitamin B₃ or niacin is involved in energy metabolism and detoxification reactions for xenobiotics. Vitamin B₅ or pantothenate is particularly involved in the fatty acid metabolism, whereas vitamin B₆ is involved in the amino acids metabolism. Finally, vitamin B₉ or folate is essential for new cell production and growth (Economos & Clay, 1999; Anonymous, 2001). Nowadays, deficiencies in the complex B-vitamins is uncommon, although sub-clinical deficiency can be found, particularly in distress conditions, as for example among refugees with a poor feeding (Anonymous, 2001).

Citrus fibre is mainly constituted by pectin (60-70%) along with cellulose and hemicellulose. This sort of fibre in association with lignin may contribute to the reduction of the rate of glucose uptake after carbohydrate consumption, and diminish the reabsorption of bile acids which gives rise to lowered plasma cholesterol levels.

Whereas minerals, vitamins and fibre are essential in a balanced diet for the human survival, carotenoids (pigments), phenols and essential oils may have a role in other biological processes, preventing or curing some diseases by anti-radical and anti-inflammatory processes. These secondary metabolites may be isolated from peel, pulp, seed, pressed oil, juice or entire fruit of diverse *Citrus* species. The amounts of such compounds depend not only of the *Citrus* species but also of the different fruit parts, which may affect the biological properties since they can be related (Lv *et al.*, 2015).

The antioxidant and anti-inflammatory activities have been attributed particularly to flavonoids (hesperitin), and phenolic acids (caffeic, chlorogenic, and ferulic acids). The anti-inflammatory activity was also reported for several *Citrus* species, and the compounds involved in this property included flavonoids (naringin, naringenin, hesperidin, nobiletin, quercetin), essential oils (limonene), and coumarins (auraptene, imperatorin). Such activities were determined using several *in vitro* (both free-system cells and cell cultures) and *in vivo* methodologies (Lv *et al.*, 2015 and references therein).

In addition, essential oils of Citrus may also present anti-microbial activity. In a recent review made by Favela-Hernández *et al.* (2016), they reported the antibacterial activity of *C. sinensis* essential oils, with different concentrations, against several bacteria (*Escherichia coli*, *Pseudomonas aeruginosa*, *Staphylococcus aureus* including those that are methicillin resistant (MRSA), *Bacillus subtilis*, *Shigella*, *Listeria monocytogenes*, and *Salmonella typhimurium*).

Citrus limonoids, which are triterpenic compounds, have anticancer activity in the presence of a variety of different animal models (stomach, lung, skin cancer, human colon adenocarcinoma cells, and human breast cancer cells, among others) (Ejaz *et al.*, 2006; Lv *et al.*, 2015). However, flavonoids, coumarins and carotenoids have also demonstrated to be inhibitors of some cancer types (Lv *et al.*, 2015). In addition, citrus derived-flavonoids also are able to decrease blood cholesterol and triglycerides, and blood glucose (Lv *et al.*, 2015). Such properties are particularly attributed to polymethoxylated flavonoids (nobiletin, tangeretin) as well as to the flavanones hesperetin, naringenin, naringin and neohesperidin (Lv *et al.*, 2015).

Other attributes have been reported for several species of *Citrus* genus such as relaxant, sedative and anxiolytic activities. Such properties are due particularly to the essential oils whereby they have been used in aromatherapy (Favela-Hernández *et al.*, 2016).

Overall, considering the presence of all those bioactive compounds in citrus fruits and juices, they should be part of a balanced diet in order to prevent some diseases and consequently promote human health. If the type and content of such compounds are dependent on diverse factors (species, varieties, plant part, stages of maturity, environmental conditions during growth, storage conditions and postharvest treatments) (Duarte *et al.*,

2016), the beneficial attributes may also change, therefore great efforts must be done in order to guarantee always a high quality final product.

6. CONCLUSIONS

Citrus fruits are a heterogeneous group of fruit trees with canopies of different types, spherical or weeping, with heights ranging from a few tens of centimeters to several meters. They are used as ornamental and for fruit production. The fruits can be of different shapes, sizes and colors. This group includes elongated lemons, spherical oranges and flattened mandarins. The fruit size ranges from small kumquats and calamondins to large grapefruits and pummelos, reaching one or more kilograms. Regarding the color, the oranges have the color that was named after their own name. But we can find citrus of other colors, from yellow lemons and green limes, to deep red blood oranges, passing through a wide range of shades of orange.

Citrus fruits, although they come from Asia, are part of the history and culture of the Mediterranean; they were adopted in the region, having become part of it. The citrus orchards interspersed with other species, decorate the Mediterranean landscape, forming multicolored mosaics of rare beauty and give it the golden touch characteristic of the most beautiful jewels. They decorate fields and cities, are in backyards and in the interior of houses.

Lemons, oranges and mandarins enter the recipes of many dishes and sweets from the Mediterranean diet, enhancing the flavor and enriching their nutritional value. They are essential for a rich and balanced diet containing many bioactive compounds with important role in preventing and even curing diseases.

Citrus fruits are thus one of the characteristic elements of the Mediterranean diet, giving it greater richness and diversity and contributing to its beneficial effects on human health.

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