Obtaining Antioxidants from Botanic Matrices Applying Novel Extraction Techniques

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Abstract
Botanic matrices are abundant sources of antioxidants which have the capacity to avoid the lipid oxidation of food and present remarkable health benefits. The natural antioxidants might be obtained applying many extraction techniques. Satisfactory results of obtaining extracts with antioxidant properties and high yields using modern extraction techniques are shown by recent studies. The selection of the suitable technique depends on the desired class of substances to be extracted. In this overview, the advances reached in scientific researches involving natural antioxidants are presented. The advantages and potential applications of four novel extraction techniques: Supercritical Fluid Extraction, Pressurized Liquid Extraction, Microwave Assisted Extraction and Ultrasound Assisted Extraction are discussed, considering the characteristics of the target compounds. These techniques reduce the solvent consumption and abridge the extraction time. Consequently, the process productivity is increased.

Keywords
Antioxidants, Bioactive Compounds, Flavonoids, Phenols, Phytochemicals, Pressurized Liquid Extraction, Supercritical Fluids

1. Introduction
The interest in the prevention of chronic diseases, such as cancer, has led to modifications in the nutritional composition of foods in the last years. These modified foods are classified as functional foods because they contain, besides the basic nutrition, components that provide health benefits[1]. The continued ingestion of food supplemented with antioxidant substances cause inhibitory effects on the proliferation of carcinogenic cells in human beings[2-4]. These effects appear because the antioxidant substances are able to perform some functions, as free radical scavenging, peroxide decomposition, suppression of singlet oxygen, enzymatic inhibition[1] and increasing the levels of endogenous defences[5].

In general, there are two categories of antioxidants: natural and synthetic. The natural antioxidants comprise a wide variety of substances found in the nature, such as polyphenols (flavonoids and phenolic acids), terpenoids and vitamins E and C. The phenolic compounds present high antioxidant capacity in biologic and food systems, especially the flavonoids group[6].

The identification of the chemical composition of extracts from several botanic matrices that present agents with potential antioxidant properties has been the focus of many studies in food and health fields. Some antioxidants are thermolabile, sensitive to light and they interact with polar and nonpolar solvents by different mechanisms. These characteristics can change the extraction yield and the quality of the extract recovered. The objective of this overview is to report the advantages associated with some modern extraction techniques for obtaining natural antioxidants. The extraction technique more suitable for the extraction of a given target group is indicated.

2. Natural Antioxidants and Their Health Benefits
In this section, the beneficial health effects exercised by phytochemical compounds with antioxidant properties are briefly gathered. Epidemiologic studies showing experimental evidences of the relationship between better health and diets rich in food containing these phytochemicals are referenced. Emphasis is given to recent studies which show the current results of ingesting natural antioxidants as polyphenols, terpenoids and vitamin E.

2.1. Polyphenols
Polyphenols are defined as substances which contain an aromatic ring attached to one or more hydroxyls, including their functional derivatives[7]. A wide variety of phenolic derivatives with antioxidant capacity is found in botanic matrices, including simple phenols, benzoic and cinnamic acids derivatives and flavonoids.
2.1.1. Flavonoids

Flavonoids are secondary metabolites of low molecular mass produced by plants, which belong to the class of phenolic compounds and present high antioxidant activity[7]. They act as antioxidants because they have many active sites to scavenge free radicals[8]. The flavonoids are divided into groups according to their chemical structures, as flavones and isoflavones, flavanones, flavonols, flavanols and anthocyanins (Table 1).

Living organisms have an oxidation-reduction system necessary to keep the level of generated free radicals constant. The formation of free radicals in higher levels than the ideal induces cellular oxidative stress that leads to lipid peroxidation of the cellular membrane, which can cause degenerative diseases and aging[9]. Therefore, scientific investigations search for solutions to avoid the cellular oxidation by the supplementation of antioxidant compounds in food. There are evidences that flavonoids, flavanones and anthocyanidins have beneficial effects to the memory, perception and neurodegeneration[10].

Hemodialysis patients face an elevated risk of cancer, ascribed in part to increased oxidative stress. Anthocyanins, present at high amounts in red fruits, show a good efficacy on the reduction of the oxidative damage in these individuals through the decrease on the risks of DNA oxidation and on the lipid and protein peroxidation[11].

Saponarin, an antioxidant belonging to the flavones group and that was recently found in barley leaves, inhibited the malonaldehyde formation. In a normal reaction, malonaldehyde is formed from oxidized lipids on the skin surface by ultraviolet irradiation[12].

Naringin, a dietetic flavanone, is an effective antioxidant for the prevention of oxidative stress and for the protection against liver carcinogenesis in rats[13]. In human beings, phenolic extracts obtained from apple and grape containing flavonoids showed potential protection of lung cells exposed to the oxidative stress[14].

Proanthocyanidins extracted from blueberry (Vaccinium angustifolium) are able to reduce the cognitive function loss by the protection against the deficient Ca$^{2+}$ recovery and moderate oxidative / inflammatory stress signalling[15]. Flavonoids extracted from fennel (Foeniculum vulgare) present antitumoral effect by modulating the lipid peroxidation[16]. Flavonoids extracted from carob (Ceratonia siliqua), mostly the miricetin, caused biochemical changes in rats physiological system, suggesting protection of liver and renal cells by the capacity of free radicals scavenging[17].

Flavanols extracted from lychee (Litchi chinensis) were supplemented on the diet of 20 healthy male long-distance runners. The decrease of the cellular oxidative stress and the reduction of the tissue damage caused by high-intensity exercise training were observed[18].

2.1.2. Non-flavonoids

The non-flavonoids compounds are phenolic acids which present a functional carboxyl group, divided into benzoic and cinnamic acids derivatives[7]. Hydroxycinnamic acids are present in many foods, such as coffee, yerba mate, apple and plum (Table 1)[19]. The phenolic acids present important biologic and pharmacologic properties, particularly on cancer prevention[20].

Caffeic acid, a hydroxycinnamic acid found in high concentrations in fruits and coffee beans, induces the apoptosis of human breast cancer cells[21]. The use of this phytochemical for the protection against disturbances of the antioxidant defense system has been tested as the possible mechanism whereby botanical compounds slow down the skin aging process. Pretreatment of skin cells with caffeic acid prior UVA (ultraviolet A) irradiation inhibits cytotoxicity, induction of metalloprotease-1 (enzyme responsible for the damage caused on collagen) and free radicalsgeneration[22].

Ferulic acid is a powerful phenolic antioxidant and photo-protector obtained from plants such as corn, rice, tomato, peanut, apple, orange and pineapple. Ferulic acid decreases the absorption of UVB (ultraviolet B) radiation on human epidermis and inhibits the formation of tumors, because this compound blocks the secretion of cytokines generated after the skin is exposed to the UVB radiation[23].

2.2. Terpenoids

Terpenoids are classified according to the number of carbon atoms in their chain, β-carotene and lycopene are tetraterpenoids (carotenoids formed by 40 carbons)[24]. The main vegetal sources of carotenoids and their molecular structures are listed in Table 1.

Scientific evidences link the antioxidant properties of carotenoids with their beneficial effect against chronic diseases. Annatto (Bixa orellana) extract, constituted by carotenoids with bixin as major compound, was identified as a potential therapeutic agent for modulation of the equilibrium of reactive oxygen and nitric oxide species, two substances that induce diabetes[25]. Annatto constituents were also studied as toxic agents against a wide variety of tumor cells. Cis-bixin has the capacity of inhibiting the enzymes associated with the oxidative stress[26].

Experimental assays point out that lycopene can protect the organism against damages caused by the exposure to tobacco[27][28], and it is beneficial on the treatment of acute and chronic pancreatitis by reducing intracellular free radicals[29]. β-carotene can help the prevention of prostate cancer[30] and gastric carcinoma[31].

2.3. Vitamin E

The supplementation with vitamin E in the diet of 180 healthy elderly people during 4 months apparently alleviates the oxidative stress by improving the erythrocyte membrane fluidity and by reducing the erythrocyte hemolysis[32]. Vitamin E tested in rats inhibited the formation of oxygen reactive species, decreased the level of lipid peroxide, increased the levels of glutathione and lipid peroxidation enzymes and presented the capacity to prevent the mitochondrial apoptosis[33].

Vitamin E identified in garlic extract was tested against the cellular oxidative stress in rats. This phytochemical
helped on the protection of the liver structural integrity due to free radicals scavenging capacity[34]. Other beneficial health effects provided by vitamin E include cardiovascular diseases prevention[35], chemopreventive actions against skin cancer[36] and induction of apoptosis of carcinogenic pancreatic cells[37]. All forms of vitamin E are able to induce antioxidant effects and to protect food and biologic membranes against the lipid peroxidation[38].

### Table 1. Classification of Some Antioxidant Compounds

| Antioxidant Compounds | Basic Structure | Examples | Main Sources |
|-----------------------|-----------------|----------|--------------|
| **Flavones**          | ![Flavones Structure](image) | Luteolin ($R_1 = R_2 = R_3 = R_4 = OH$), Apigenin ($R_1 = R_2 = R_4 = OH; R_3 = H$) and Tangeretin ($R_1 = R_2 = R_3 = OCH_3; R_4 = H$) | Parsley and Celery[39]; Lemon[40]; Tangerine[41]; Orange[42]; Oregano[43]; Rosemary[44]; Pepper[45] |
| **Flavanones**        | ![Flavanones Structure](image) | Hesperitin ($R_1 = OCH_3; R_2 = OH$) and Narigenin ($R_1 = OH; R_2 = H$) | Lemon[46]; Tomato[47]; Spearmint[48]; Orange[49]; Tangerine[50]; Lime[51] |
| **Flavonols**         | ![Flavonols Structure](image) | Quercetin ($R_1 = R_2 = R_3 = R_4 = OH; R_5 = H$), Myricetin ($R_1 = R_2 = R_3 = R_4 = R_5 = OH$) and Kaempferol ($R_1 = R_2 = R_3 = OH; R_4 = R_5 = H$) | Chamomile[52]; Yerba Mate[53]; Cashew[54]; Apple[55]; Strawberry[56]; Spinach[57]; Tomato[47]; Rosemary[44]; Oregano[43] |
| **Anthocyanins**      | ![Anthocyanins Structure](image) | Cyanidin ($R_1 = R_2 = R_3 = R_4 = R_5 = OH; R_6 = H$), Pelargonidin ($R_1 = R_2 = R_3 = R_4 = OH$) and Malvidin ($R_1 = R_2 = R_3 = OCH_3; R_4 = R_5 = R_6 = OH; R_7 = H$) | Grape[58]; Raspberry[59]; Cherry[60]; Strawberry[56]; Jabuticaba[61]; Pomegranate[62]; Plum[63] |
| **Catechins**         | ![Catechins Structure](image) | Epicatechin ($R_1 = R_2 = R_3 = OH; R_4 = H$) | Spearmint[48]; Cocoa[64]; Strawberry[56]; Apple[55]; Green and White Tea[53] |
| **β-carotene**        | ![β-carotene Structure](image) | - | Carrot and Sweet Potato[65]; Beet, Turnip, Pear and Peach[66]; Apricot[67]; Papaya[68]; Pumpkin[69]; Buriti, Tapioca, Caruru, Mint, Parsley and Tucumã[70] |
| **Lycopene**          | ![Lycopene Structure](image) | - | Tomato[71]; Papaya[72]; Watermelon[73]; Guava[74]; Pitanga and Maracujá[70] |
| **Vitamin E**         | ![Vitamin E Structure](image) | α-Tocopherol ($R_1 = R_2 = R_3 = OH$) and β-Tocotrienol ($R_1 = CH_3; R_2 = H$) | Sunflower[75]; Peanut[76]; Soybean[77]; Lettuce[78]; Banana[79] |
| **Hydroxyecinnamic acids** | ![Hydroxyecinnamic acids Structure](image) | Coumaric Acid ($R_1 = OH; R_2 = H$), Caffeic Acid ($R_1 = R_2 = OH$) and Ferulic Acid ($R_1 = OCH_3; R_2 = OH$) | Cherry[80]; Coffee[81]; Melon[82]; Apple[55]; Yerba Mate[53]; Strawberry[56]; Grape[58]; Pepper[45] |
3. Modern Techniques for Extraction of Antioxidants

Antioxidants are substances that, in low concentrations, inhibit or prevent the oxidation of other substances[83]. Many foods still contain synthetic antioxidants in their formulations, as Butylated Hydroxytoluene (BHT) and Butylated Hydroxyanisole (BHA), because they are thermally stable and of low cost. However, experimental investigations show that BHT and BHA are carcinogenic and cytotoxic above 500 ppm[84]. The maximum recommended BHT daily intake is 0.125 mg/kg of body mass and the maximum recommended BHA daily intake is 0.5 mg/kg of body mass. In the European Union the use of BHT and BHA is allowed[85].

Due to these issues, natural antioxidants allowing for the substitution of synthetic antioxidants are the target of many studies[86-91]. Boo et al[92] demonstrated high antioxidant activities of natural pigments found in onion (Allium cepa L.), red cabbage (Brassica oleracea L.), mulberry (Morus alba L.), purple sweet potato (Ipomoea batatas L), yellow paprika (Capsicum annum L.), red beet (Beta vulgaris L) and grape (Vitis vinifera L.).

Botanic matrices are abundant sources of nutraceutical compounds. The natural antioxidants, belonging to the GRAS (Generally Recognized As Safe) group of FDA (Food and Drug Administration), are extracted from herbs or plants and are commonly phenolic compounds that present health benefits, as the prevention of diabetes, cancer, hypertension, asthma and infections[93],[94].

The separation or the isolation of the target compounds from their original matrix is the method used to obtain these antioxidant substances. Conventional extraction techniques (steam distillation and Soxhlet extraction, for instance) possess some drawbacks due to the use of high temperatures and/or high amounts of organic solvents; another limitation is that the steam distillation process can be used only to obtain volatile oils (mostly terpenes). These conventional techniques are being substituted by novel techniques, as supercritical fluid extraction (SFE)[95-98]; pressurized liquid extraction (PLE)[90],[99],[100]; microwave assisted extraction (MAE)[101-103]; and ultrasound assisted extraction (UAE)[104],[105]. The choice of the suitable technique depends on: the desired class of compounds to be extracted; the structural characteristics of the botanic matrix (fruits, stems, seeds, leaves, root, flowers, etc.); the quality and yield required for the extract; the process conditions (temperature, pressure, etc.) and the economic feasibility for scaling up the process.

For instance, SFE using pure CO₂ is more appropriate for extracting nonpolar compounds as terpenoids, tocopherols and sitosterols[106], while PLE is more appropriate for extracting polar antioxidants as the phenolic compounds: anthocyanins[107] and flavonols[108]) using solvents with high polarity. MAE is an extraction technique indicated when the botanic matrix contains large amounts of water, because the water is responsible for the absorption of the energy generated by the microwaves. This energy disrupts the cells and facilitates the release of chemical constituents[109]. The UAE technique is also suitable for obtaining antioxidants. The characteristic of UAE is the reduced solvent consumption[110], the possibility of processing several samples in the same equipment and the short extraction time[109].

The solvent selection for the extraction is based on some factors, as: physicochemical properties, availability, cost and toxicity. The choice of the ideal solvent should consider its selectivity, as well the solute solvating capacity, interfacial tension, viscosity, stability and reactivity[109].

3.1. Historical Aspects

The application of supercritical technology in obtaining bioactive compounds has evolved over the past decade. However, the divulgation of the investigations related to this area in patent form started in the early of 1970 when the first patent comprising a process for recovering caffeine from green coffee using carbon dioxide in supercritical conditions was registered by Zosel[111]. In 1981, another patent was published dealing with the decaffeination of coffee[112]. From that date to now, over than 300 patents were registered and are available at “Web of Knowledge” database. One of these recent patents comprises a useful method for preparing carotenoid microcapsules with a controllable isomeric ratio applying a supercritical fluid at high temperatures[113].

In the same way, another invention utilizes olive by-products for the isolation and separation of tocopherols with supercritical fluids[114]. In 1997, an inovative study was published dealing with the effects of ultrasound on mass transfer in SFE[115]. This coupled system has been investigated currently in the extraction of lutein esters from marigold[116] and of oil from adlay seed[117].

The number of scientific investigations published after the year 2000 comprising modern extraction techniques for obtaining antioxidants has significantly risen by 2012. Figure 1 shows this tendency, whereby searches in “Scopus” and “Web of Knowledge” database inserting the terms “SFE and antioxidant” returned together more than 780 documents in the year 2012, while less than 80 documents covering the same subject were published in the year 2000. The same search procedures were used for PLE, MAE and UAE. These novel techniques also present an important evolution in the scientific scenario, mainly in the last five years where the number of publications related to MAE and UAE in Scopus, for instance,increased from 150 and 102 to 551 and 393, respectively. The participations of SFE, PLE, MAE and UAE in obtaining natural antioxidants referent to the overall techniques in 2003 have been 5.9%, 1.0%, 1.4% and 0.9%, respectively. In 2012, these relative participations have increased to 9.5%, 4.3%, 7.5% and 5.4%, respectively. Therefore, the contribution of both techniques in 2003 has been 9.2%, while in 2012 it has been 26.7%, almost 3 times higher than ten years ago.
Solvents is characterized by low selectivity and may require high pressures. At this condition, the co-extraction of other undesirable compounds, as waxes and oleoresins, might happen. When the co-extraction of these compounds cannot be avoided, several separator vessels can be displayed in series, operating at different temperature and pressure conditions, to fractionate the extract[120].

Belonging to the Lamiaceae family, rosemary (Rosmarinus officinalis) is a plant with powerful antioxidant agents. Carnosic acid (CA) and carnosol are the major phenolic diterpenes present in rosemary extracts obtained by SFE, as shown by Kuo et al.[121]. The CA content obtained in the referred study was approximately 110 mg/g extract, resulting in IC₅₀ of 7.47 µg/cm³. The IC₅₀ is the concentration of extract or active compound needed to inhibit 50% of oxidation of a defined substance, which can be determined by the DPPH (2,2-diphenyl-1-picrylhydrazyl) test. An IC₅₀ of 7.47 µg/cm³ is very attractive, because low concentrations of CA present significant effects on the free radicals scavenging. At the concentration of 80 µg/cm³, CA presented inhibition of 84.1% of the lipid peroxidation, while the synthetic BHT antioxidant inhibited 80.8% of the lipid peroxidation.

The results obtained by Kuo et al.[121] corroborate the studies carried out by Vicente et al.[89] using rosemary leaves; the authors obtained high CA content in the extract in 1 h of extraction by SFE. The antioxidant activity of the extract increased with the extraction time because the volatile oil is depleted from the vegetal matrix at the beginning of the process, and the phenolic compounds, which present higher antioxidant activity, are only later extracted.

Antioxidants are compounds usually sensitive to light and heat. The antioxidants obtained by SFE have the advantage of being processed under the absence of light and at moderate temperatures. Furthermore, they are easily separated from the solvent and they hardly suffer undesirable oxidation reactions. Recently, natural antioxidants with high activity were obtained by SFE from mint (Mentha spicata L.) leaves[122],[123], coffee (Coffee arabica) grounds[96], green tea (Camellia sinensis) leaves[124], grape (Vitis vinifera L.) seeds[97], thyme (Thymus vulgaris) flowers[125], guava (Psidium guajava L.) seeds[86], orange (Citrus sinensis L.) bagasse[126] and rosemary (Rosmarinus officinalis) leaves[127].

The interest in SFE has been increasing in the last years, which is shown by the several studies found in literature dealing with this topic (Figure 1). One of SFE features is that the raw material must be dried prior to the extraction with supercritical CO₂. The water decreases the efficiency of this technique by limiting the contact between the CO₂ and nonpolar solutes[120]. The water present in the solid material may also compete with CO₂ to dissolve the solute, which affects the mass transfer rate. Considering these aspects, the drying of the raw material at ideal conditions, without causing degradation of the bioactive compounds, is required[109].

3.2. Supercritical Fluid Extraction (SFE)

Extraction of bioactive compounds with conventional solvents is characterized by low selectivity and may require high temperature[118]. Because of these limitations, SFE has some characteristics that justify its use for obtaining natural antioxidants. CO₂, the solvent mostly used in SFE, presents critical temperature of only 304 K, which allows its use for the extraction of thermo sensitive (thermolabile) compounds. Several phytochemicals show high solubility in CO₂ around supercritical conditions (304 K/7.4 MPa).

Bioactive compounds extracted from botanical matrices by SFE technique present a pronounced reproduction of the sensory characteristics of the raw material when compared to conventional techniques. The thermal degradation and the decomposition of thermolabile substances are strongly reduced, since the SFE procedure occurs at low temperatures and in the absence of oxygen and light. This feature is especially useful in the extraction of antioxidants, because it guarantees the conservation of their functional properties[119]. Moreover, SFE is more selective than the conventional extraction techniques, and it is suitable for obtaining solvent-free products[118].

![Figure 1. Number of documents published in Scopus and Web of Knowledge databases in the range of years 2000-2012 on modern techniques for the extraction of antioxidant compounds. SFE: supercritical fluid extraction; PLE: pressurized liquid extraction; MAE: microwave assisted extraction; UAE: ultrasound assisted extraction](image-url)
Supercritical CO₂ is a solvent appropriate to extract nonpolar solutes. Compounds presenting high molecular mass, as flavonoids, are poorly soluble in pure CO₂. In such case, the addition of a polar cosolvent to the CO₂, to form a mixture with it in ideal proportions, improves the solubility of polar organic compounds. Thus, the mixture CO₂ + cosolvent can increase the mass transfer rate. The solubility improvement in the supercritical region is associated with molecular interactions, mostly hydrogen bonds[128].

The extraction of polyphenolic antioxidants by SFE with cosolvents was studied by various authors. Phenolic diterpenes were obtained from rosemary using 10% (w/w) of ethanol[129] and flavones were extracted from chamomile (Matricaria recutita) using 20% (w/w) of ethanol[130]. Water was employed as a cosolvent for extracting phenols from sweet basil (Ocimum basilicum)[131] and antioxidant compounds from sunflower (Helianthus annuus)[132] at proportions of 20% (w/w) and 5% (w/w), respectively.

Ethanol and water are the most appropriate solvents to be applied in the food industry. Ethanol is widely used to increase the efficiency of the extraction of phenolic acids and flavonoids, and is easily removed from the final product by distillation[120],[133]. The cosolvents commonly used to extract antioxidant compounds are listed in Table 2.

Table 2. Cosolvents Used in Supercritical Fluid Extraction (SFE) of Antioxidant Compounds

| Cosolvent     | Class of Compounds | EY† | Reference |
|---------------|--------------------|-----|-----------|
| Ethanol       | Polyphenols        | 14.0| [96]      |
|               | Flavonoids         | 2.2 | [130]     |
|               | Phenolic Acids     | 2.4 | [126]     |
| Ethyl Acetate | Phenolic Acids     | 3.8 | [136]     |
| Methanol      | Phenols            | 4.0 | [137]     |
| Vegetable oils| Carotenoids        | 3.0-3.7| [138],[139]|
| Water         | Phenols            | 25.0| [131]     |

† Number of times the yield increases compared to the yield with pure CO₂.

The interactions between solute and solvent in the SFE process can be studied considering a solution of infinite dilution because the solubility of the bioactive compounds is low in supercritical CO₂, and, moreover, usually the solution is far from saturation. This fact makes the equilibrium study simple in systems where only CO₂ is used as solvent. On the other hand, the critical temperature and pressure change when cosolvent is added depending on its fraction in the mixture. As an example, for the system CO₂ + ethanol the critical point moves from 310.6 K and 7.77 MPa for 0.0044 mol% ethanol to 410.3 K and 15.17 MPa for 0.403 mol% ethanol[134]. The temperatures above 330 K are not recommended for processing thermo sensitive compounds, the existence of two phases inside the extractor is common when using high fractions of cosolvent. Despite the fact that the process can be performed using such system, in this case it presents a behaviour that cannot be predicted by the models used for CO₂ alone. Therefore, when using cosolvents the system is much more complex than for CO₂ alone and each case should be individually studied. Increasing the cosolvent fraction above 50% changes the process to PLE, where ethanol is the solvent and CO₂ is the cosolvent, when the latter is used.

Another recent trend concerning cosolvents is using vegetable oils as modifiers. In the extraction of carotenoids by SFE, it not only allows recovering compounds that have low solubility in CO₂, but it also leads to the production of carotenoid-rich vegetable oils. Canola, olive, hazelnut, sunflower seed, soybean and rapeseed oils have been used for this purpose, among others[135].

3.3. Pressurized Liquid Extraction (PLE)

The PLE technique is an alternative that has been recently used to obtain bioactive compounds; it uses an aqueous or organic solvent at high pressure and/or temperature by circulating the solvent through the sample. High pressure is not the most important feature in PLE process. In fact, most often the purpose of raising the pressure is to keep the solvent in the liquid phase. Designations for PLE can be found in literature, as accelerated solvent extraction (ASE), pressurized hot solvent extraction (PHSE), pressurized water extraction (PWE), high pressure solvent extraction (HPSE) and subcritical solvent extraction (SSE), among others. Antioxidants can be obtained using solvents at temperatures above their boiling point. For these reasons, a generic term is used: “superheated solvent extraction” (SHSE)[140]. Liquid carbon dioxide cannot be used in this case because its critical temperature is low (at about 304 K) compared to the temperatures used in PLE. So, at pressures and temperatures above the critical point of CO₂ the process is called SFE.

Flavonoids, catechins, anthocyanins, flavanones, and flavones are some of the phenolic compounds which were obtained using PLE[107],[108],[141-144]. King and Grabiel[145], in their patent, demonstrated the potential of PLE technique for extracting polyphenols from fruits and vegetables wastes. Also, a method for extraction of phenols from grape skins by ASE using ethanol-water mixtures is found in literature[146].

In PLE, high temperature is usually attractive, because it improves the extraction yield. The increase in temperature modifies the solvent dielectric constant and the solute solubility in the solvent[109]. Studies show that polyphenol extracted at temperatures above 363 K are unstable and can suffer pronounced thermal degradation, although the quantity of antioxidants extracted is high at elevated temperatures[107],[147],[148].

Comparative assays using PLE and conventional extraction techniques were carried out for obtaining the three major flavones (hesperitin, nobiletin and tangeretin) present in tangerine peels (Citrus reticulata). The flavones were efficiently extracted by PLE, reaching higher yields than the conventional methods. Additionally, the extraction time was lower for PLE[141].

The recovery of polyphenolic compounds from oregano leaves (Origanum vulgare) by PLE was tested by Miron et al.[149]. The operational conditions used in the experimental assays
were temperatures of 323 K, 373 K, 423 K and 473 K, and different proportions of ethanol/water as solvents. The extracts obtained using PLE with 100% of water in batch mode applying an 11 cm³ extractor at 323 K and 10 MPa presented the highest amount of phenols and the highest antioxidant activity. Under these conditions, the total phenol content was 184.9 mg GAЕ/g extract, where GAЕ means “gallic acid equivalents”. The antioxidant activity was established as the amount of extract necessary to reduce the DPPH concentration in 50%, resulting in IC₅₀ of only 6.98 µg/cm³. When pure ethanol was used as solvent at temperature of 373 K, the total phenols content was only 102.2 mg GAЕ/g extract and the IC₅₀ was 11.5 µg/cm³. These results suggest that the solvent and the temperature influenced both the extract yield and its quality[149].

Recovery of anthocyanins and phenolic compounds from jabuticaba (Myrciaria cauliflora) was studied applying PLE and Low-Pressure Solvent Extraction (LPSE). Similar yields were obtained using both techniques. However, the PLE technique was attractive because it resulted in a rapid process (~ 9 min) and it allowed low solvent consumption. The content of anthocyanins and total phenols in PLE extract were 2.15 and 1.66 times higher, respectively, than their content in LPSE extract. Moreover, PLE extract than in cost of manufacturing 40 times lower than LPSE extract due to the short processing time[150].

PLE technique is usually appropriate for obtaining antioxidants from lignocellulosic materials. Some of the effects achieved under temperatures of hydrothermal treatment (for instance above 493 K) are listed as[120]:

i) solubilization of acid-soluble lignin;
ii) hydrolytic depolymerization of hemicellulose into compounds of high molecular mass (soluble fibers);
iii) extraction of lipophilic compounds;
iv) extraction of lignans;
v) extraction of non-saccharides as terpenes, fatty acids and monomeric phenols.

The phenolic compound vanillin was the major component with antioxidant activity found in barley husks subjected to non-isothermal auto-hydrolysis in aqueous medium[151]. The solubilized portion obtained in the auto-hydrolysis of pine (Pinus radiata) using several tests (DPPH radical scavenging, hydrosyl radical scavenging, Trolox equivalent antioxidant capacity, β-carotene bleaching and reducing power) presented specific antioxidant activity 40 times higher than BHT, 25 times higher than α-tocopherol, 8 times higher than caffeic acid, 3.5 times higher than BHA and 3 times higher than gallic acid[152].

PLE differs from conventional techniques because PLE uses high temperature and pressure in extractive process, which may be conducted in semi-continuous (dynamic) or batch (static) modes. A wide range of temperature might be applied; it usually varies between 293 K and 473 K. The pressure commonly used varies between 3 MPa and 20 MPa[153]. Therefore, PLE is a suitable technique for extracting several solutes, both polar and nonpolar. PLE has been used as an alternative for obtaining antioxidant substances with high molecular mass derived from the hemicellulose fragmentation[120].

3.4. Microwave Assisted Extraction (MAE)

MAE is another innovative technique that has been presenting special interest. Microwaves consist of nonionizing electromagnetic energy with a frequency from 0.3 GHz to 300 GHz that is applied directly to the raw material. They transmit energy which penetrates into the biologic matrix and interacts with polar molecules, mostly water, generating heat; the heat expands and disrupts the vegetal cell, favoring the extraction of intracellular phytochemical compounds. MAE is a technique frequently used for extracting thermolabile compounds[109].

Extraction of polyphenolic compounds from cherry (Prunus cerasus) pulp was performed using the MAE method in batch mode by Simsek et al.[103]. Epicatechin (flavanol) was the major phenolic compound extracted, and its concentration was higher when using the MAE technique than when using the conventional technique. The antioxidant efficiency of MAE extract was 28.32 mg DPPH/g sample[103]. Antioxidants present in deoiled rosemary (Rosmarinus officinalis) leaves were extracted by MAE using ethanol and water as solvents. Carnosic acid and carnosol were responsible for most of the antioxidant activity found in the extract. The IC₅₀ values using water and ethanol as solvents were 22.8 µg/cm³ and 41.0 µg/cm³ respectively[154].

Onion (Allium cepa) varieties are rich in quercetin (flavonol). Their flavonoids content and antioxidant activity were evaluated using MAE as the extraction technique. The red onion variety exhibited the highest antioxidant activity. According to the DPPH test, the IC₅₀ was 17.09 mg/cm³ and the total amount of quercetin extracted was 134.7 mg/100 g dried sample[155].

In a recent study, the antioxidant activity of polyphenol compounds present in pomegranate (Punica granatum) peels was evaluated using the MAE technique with water as solvent. Pronounced polyphenols yields were reached (210.4 mg GAЕ/g extract). The IC₅₀ was 14.53 µg/cm³ (DPPH test), confirming an elevated antioxidant capacity of pomegranate extract[156]. Figure 2 shows the free radical scavenging capacity of the pomegranate extract evaluated by the DPPH test. The polyphenol compounds extracted by MAE have activity equivalent to the synthetic BHT antioxidant in concentrations over 40 µg/cm³. At this concentration, the antioxidant activity of pomegranate extract and BHT were over 90%, indicating MAE as a potential alternative for obtaining natural antioxidants.

The conventional solid-liquid extraction can generate undesirable residues with products. In addition, the extract can suffer oxidative transformations during the solvent removal step[119]. Several scientific investigations report MAE applicability for obtaining natural antioxidants, without generating undesirable residues, as the extraction of polyphenols from peanut skins[157], whole tomato (Solanum spp.)[101], grape (Vitis vinifera) seeds[158], sweet potato (Ipomoea batatas) leaves[159] and bean (Phaseolus...
MAE process is short, usually from 2 min to 40 min. This fact makes MAE an attractive technique, since for thermolabile compounds long extraction times can result in degradation and consequent antioxidant capacity loss[101].

The results obtained using MAE are satisfactory because the microwaves cause molecular motion due to the migration of ionic species and dipole rotation. Therefore, the microwaves effect is proportional to the medium dielectric constant and to the solid matrix. In addition, the increase of the process temperature improves the solvent penetration [109].

Considering these aspects, the solvent selection should be made taking into account its dielectric constant. Polar molecules and ionic solutions have permanent dipole moment and strongly absorb the energy of microwaves. Therefore, ethanol, methanol and water are ideal solvents, while hexane and toluene have low dielectric constants and are not recommended for MAE[109],[162].

3.5. Ultrasound Assisted Extraction (UAE)

Most of extraction techniques consist of the manipulation of the solvent physical properties to reduce its superficial tension, to increase the solute solubility and to improve the mass transfer rate; in some cases, these manipulations also induce changes in the solvent polarity[109].

The UAE technique consists in using mechanic vibrations caused by sound waves with frequencies higher than 20 kHz. Sound waves are intrinsically different from electromagnetic waves, because the latter can propagate through the vacuum, while sound waves need a physical medium to propagate. The mechanic vibrations cause expansion and compression cycles in the medium, creating bubbles which collapse and cause cavitation, instantly creating a high local pressure and intense local heating. These fast changes induce disruption and thinning of the cell membranes, consequently increasing the mass transfer rate of organic substances from the solid matrix to the solvent[109],[163].

The advantages of UAE technique include the simplicity of the equipment and the possibility of using different solvents for the extraction, including water-ethanol mixtures[163]. In food and pharmaceutical fields, UAE is used to extract several bioactive compounds from botanic matrices, as flavonoids[104],[164],[165], polyphenols[166],[167], alkaloids[168], terpenoids[169] and anthocyanins [105],[170]. The improvement of extracting bioactive compounds when applying ultrasounds is attributed to the mass transfer rate increase due to the solvent cavitation induced by the ultrasounds wave passing through the medium[154].

An efficient extraction procedure for recovering antioxidant compounds from jabuticaba (Myrciaria cauliflora) skins was proposed in literature: 10 min of UAE + conventional agitated bed extraction (ABE). This combination maximized the extraction of polyphenols and resulted in extracts with high antioxidant activity. At 30 min of reaction (based on the couple oxidation of β-carotene and linoleic acid), the antioxidant activity of the extracts obtained using UAE + ABE was over 85%, while the ABE process presented extracts with antioxidant activity under 65%. Furthermore, UAE + ABE was the best option from the economic point of view, because the extract obtained by this combined technique presented the lowest cost of manufacturing (US$ 387.2/kg of crude extract)[61].

Considerable concentrations of rosmarinic acid (6.36 mg/cm³) and total phenols (8,790 ppm GAE) were obtained from deoiled rosemary (Rosmarinus officinalis) leaves applying the UAE technique and water as solvent. The high concentration of antioxidants in the extract resulted in high antioxidant activity and the IC₅₀ was 23.6 µg/cm³. The IC₅₀ was measured by DPPH test[154].

In extraction of leek (Allium porrum) stem by UAE, 69.5 mg GAЕ/g e xtract was obtained. The antioxidant activity of the extract was compared to the standard antioxidants: vitamin C and BHT. The IC₅₀ value of the ethanolic extract was 61.1 µg/ cm³. Although theIC₅₀ value of the ethanolic extract was higher than the IC₅₀ of vitamin C (IC₅₀ = 10.6 µg/cm³) and BHT (IC₅₀ = 39.2 µg/cm³), the inhibition composition of the ethanolic extract was very low. Thus, the leek extracts can be used in the industry as efficient agents against oxidation[171].

A certain amount of water (40% - 60%) should be added to the solvent in order to obtain satisfactory yields in UAE, because water increases the extraction of flavonoids and other polar compounds. Water addition increases the medium relative polarity and facilitates the propagation of the ultrasonic waves[110]. Using UAE with water as solvent was efficient for reaching specific hydroxylation of polyphenols and carotenoids in order to increase their bioactivity[172].

Ultrasound is also a broad method that can be done not
only with solvent at atmospheric pressure. The combination of UAE followed by re-extraction of obtained extract by SFE was performed aiming to concentrate diterpenes present in sage extract. The diterpenes are generally considered to be responsible for antioxidant activity of the extracted compounds[173].

The coupled system of high-intensity ultrasound + SFE is an efficient manner of enhancing mass transfer in extraction processes. In this sense, a supercritical CO2 extraction of oil from particulate almonds was performed using power ultrasonic transducer with a frequency of 20 kHz. The process performance was evaluated, showing that this system conducted to a 30% increased yield[174]. The same procedure was used for obtaining extract from ginger. In the presence of ultrasound within the supercritical medium, both the extraction rate and the yield increased. Generally, the initial stage of extraction, which is controlled by the external mass transfer, is not affected by ultrasound. Nevertheless, in the subsequent stage of extraction, which is controlled by the internal mass transfer, the ultrasound allows an improvement in the yield[175]. Recently, extracts of malagueta pepper containing capsaicinoids were obtained using SFE and SFE assisted by ultrasound. The assays carried out with ultrasound presented a yield 20% higher[176].

3.6. Summary of the Characteristics of SFE, PLE, MAE and UAE

Table 3 shows compiled information in operational conditions of the four techniques presented for extracting antioxidants. This Table is a compendium of the arguments discussed in the text. The distinguishing characteristics that make each technique more or less attractive for processing different raw materials are also included in Table 3. For instance, SFE technique does not need cosolvent when the target phytochemicals are nonpolar (terpenoids, tocopherols and sitosterols). To extract polyphenols, on the other hand, the use of cosolvents is essential. Thus, the extract quality and yield are closely related to the extraction technique and to the process conditions.

Figure 3 exemplifies the novel extraction techniques used for obtaining antioxidants: SFE, PLE, MAE and UAE. The basic schematic diagram of equipment used in each technique is presented. In the case of MAE, the extractor must be built of a material that allows the microwaves to propagate. This material is usually glass or teflon. MAEs is mostly performed in batch mode (static), while the other techniques are usually performed in semi-continuous mode (dynamic), using constant solvent flow rate in the extraction vessel. The selection of the way to promote the extractor heating is done by the researchers; in the scheme of Figure 3, the extractors of SFE, PLE and UAE are heated using a jacket.

Table 4 shows the antioxidant capacity, expressed as IC50, of compounds obtained from several raw materials using the four novel extraction techniques discussed in the text. Several studies found out high antioxidant capacities of compounds in low concentrations. Certainly, the lower the IC50 value the larger the antioxidant capacity of the extract.

Figure 3. Basic Schematic Diagram of Equipment used for the Extraction of Natural Antioxidants. SFE: Supercritical Fluid Extraction; PLE: Pressurized Liquid Extraction; MAE: Microwave Assisted Extraction; UAE: Ultrasound Assisted Extraction; 1: Solvent Reservoir; 2: Valve; 3: Pressure Gauge; 4: Cooling Bath; 5: Pump; 6: Heating Bath; 7: Separator Vessel; 8: Extract Collecting Vessel; 9: Condenser
Selection of the Extraction Technique and Operational Conditions Suitable for Obtaining Different Antioxidant Compounds

| Technique | Characteristics | Botanic Matrix | Antioxidants | Conditions | Reference |
|-----------|-----------------|----------------|--------------|------------|-----------|
| SFE       | Reduces Solvent Consumption | Grape Peels | Anthocyanins | T: 313; P: 15; S: Ethanol + Water (7:3 v/v); V: 0.022 | [186] |
| PLE       | Shortens the Extraction Time | Spinach Leaves | Flavonoids | T: 323; P: 13.8; S: Ethanol + Water (7:3 v/v); V: 0.022 | [187] |
| MAE       | Reduces Solvent Consumption | Broccoli Stalks | Phenols | T: 344; S: Ethanol + Water (7:5:2.5 v/v); Pt: 167; t: 16 | [191] |
|          | Allows the Absence of Light During the Extraction | Grape Seeds | Phenols | S: Ethanol + Water (3.7 v/v); V: 0.25; Pt: 121; t: 6 | [192] |
|          | Presents the Capacity of Processing Several Samples Simultaneously | Cumin Leaves | Phenols | T: 323; S: Ethanol + Water (5:5 v/v); Pt: 200; t: 18 | [193] |
|          | Uses Raw Material that can be Moist | Whole Tomatoes | Polyphenols | T: 370; S: Ethanol + Water (7:3 v/v); V: 0.1; Pt: 2 | [101] |
|          | Moist | Peanut Skins | Polyphenols | S: Ethanol + Water (7:3 v/v); V: 0.1; Pt: 855; t: 0.5 | [157] |

* GRAS: Generally Recognized As Safe

The lowest values of IC_{50} were found for extracts obtained from rice dye (Buddleia officinalis) (3.1 µg/cm^3), rosemary (Rosmarinus officinalis) (12.8 µg/cm^3), pomegranate (Punica granatum) (14.5 µg/cm^3) and peanut (Arachis hypogaea) (14.9 µg/cm^3).

In summary, the antioxidant capacity is a function of process conditions which are related to the selected extraction technique. Process parameters of extraction influence the concentration of target compounds in the extract. The solvent characteristics, the extraction time and the temperature interfere in the selectivity of compounds and in the antioxidant properties of the extract. Furthermore, the origin of the raw material employed is the most influence in the antioxidant power.
Almeida et al.[122] obtained mint essential oil by SFE with CO2. The highest yield (2.38%, w/w) was obtained at 30 MPa and 323 K. The IC50 in SFE extracts obtained without using cosolvent was >250 µg/cm3. However, the IC50 in SFE extracts obtained using 20% (w/w) of ethanol was 43.3 µg/cm3. So, the SFE with cosolvent is an efficient method for obtaining antioxidant compounds from mint (Mentha spicata L.), as carvone, cineole and pulegone. Nevertheless, the SFE process without cosolvent is not capable of recovering caffeine and phenols from coffee (Coffea arabica). Andrade et al.[96] reached an IC50 of 1706 µg/cm3 using SFE (CO2/20 MPa/313 K), while the IC50 was 235 µg/cm3 using UAE with ethanol as solvent, indicating UAE as a suitable technique for obtaining caffeine and phenols from coffee. MAE has been reported as an adequate technique for obtaining phenols with antioxidant properties from pomegranate (Punica granatum)[156] and phenolic diterpenes from rosemary (Rosmarinus officinalis)[154]. PLE was used for extracting major catechins from green tea, presenting advantages such as shorter extraction time and lower energy consumption[198].

Table 4. Antioxidant Capacities of Bioactive Compounds Extracted from Botanic Matrices Applying Different Extraction Techniques

| Raw Material          | Raw Material Part          | Inhibition Compounds                  | Method | Solvent       | IC50 (µg ·cm−3)* | Reference |
|-----------------------|---------------------------|--------------------------------------|--------|---------------|-----------------|-----------|
| Rosemary (Rosmarinus officinalis) | Whole Fresh Leaves        | Carnosic and Rosmarinic Acids        | MAE    | Water         | 47.0            | [154]     |
|                       | Deoiled and Milled Leaves |                                      | MAE    | CO2           | 86              |           |
|                       | Leaves                    | Carnosic Acid                        | SFE    | CO2 + Ethanol  | 15.3            | [89]      |
| Coffee (Coffea arabica) | Ground                   | Caffeine and Phenols                 | UAE    | CO2 + Ethanol  | 235.1           | [96]      |
| Daylily (Hemerocallis disticha) | Flowers               | Lutein and Zeaxanthin                | UAE    | CO2 + Ethanol  | 12.7            | [199]     |
| Mint (Mentha spicata L.) | Leaves                   | Carvone and Cineol                   | SFE    | CO2 + Ethanol  | 43.3            | [122]     |
| (Lepidium apetalum)    | Seeds                    | NI                                   | SFE    | CO2           | 1.0×10³         | [200]     |
| Sea Buckthorn (Hippophae rhamnoides) |                      | Flavonoids                           | MAE    | SF            | 710.0           | [102]     |
| Tea (Camellia sinensis L.) |                         | NI                                   | SFE    | CO2           | 35.8×10³       | [124]     |
| Mengkudu (Morinda citrifolia L.) | Leaves              | Phenols                              | UAE    | Ethanol       | 920.0           |           |
|                       |                          |                                      | SFE    | Ethanol + Water | 2.5×10³         | [201]     |
| Orange (Citrus sinensis L.) | Bagasse              | Phenolic Acids                       | UAE    | Ethanol       | 434             | [126]     |
|                       |                          |                                      | SFE    | CO2 + Ethanol  | 403             |           |
| Saramjunamu (Sapium japonicum) | Leaves              | Phenols                              | PLE    | Ethanol + Water | 109.0           | [202]     |
| Mangoesin (Garcinia mangostana) | Fruits       | Xanthones                            | UAE    | CO2 + Ethanol  | 41.8            | [98]      |
| Indian-mulberry (Morinda citrifolia) | Stem       | Polyphenols                          | SFE    | CO2           | 6.9×10³         | [87]      |
| Patrinia (Patrinia villosa) | NI                       | Terpenoids                           | MAE    | Methanol      | 32.0            | [203]     |
| Rosemary (Rosmarinus officinalis) | Leaves        | Phenolic Diterpenes                  | SFE    | Methanol      | 12.8            | [204]     |
| Black Chokeberry (Aronia melanocarpa) | Seeds      | Polyphenols                          | UAE    | Ethanol + Water | 200.0           | [166]     |
| Onion (Allium cepa)    | Bulb                     | Quercetin                            | MAE    | SF            | 17.1×10³        | [155]     |
| Leek (Allium porrum L.) | Stem                    | Phenols                              | UAE    | Ethanol       | 61.1            | [171]     |
|                       | Leaves                   |                                      | PLE    | Ethanol + Water | 98.9             |           |
| Womwood (Artemisia campestris) | Aerial Parts | Flavonoids                           | UAE    | Methanol      | 20.6            | [205]     |
| Mugwort (Artemisia suhagris) |                         |                                      | UF     | Ethanol       | 26.5            |           |
| Lemon Balm (Melissa officinalis L.) | Leaves    | Flavonoids                           | PLE    | Ethanol       | 134.2           | [206]     |
| Peanut (Arachis hypogaea) | Bark                    | Phospholipids                        | UAE    | Ethanol       | 14.9            | [104]     |
| Onion (Allium cepa)    | Bulb                     | Quercetin                            | SF     | Ethanol       | 7.0×10³         | [155]     |
| Pomegranate (Punica granatum) | Peel          | Phenols                              | MAE    | Water         | 14.5            | [156]     |
| Rice Dye (Baldkea officinalis) | NI                 | Luteolin                             | SF     | Ethanol       | 3.1             | [207]     |

NI = Not Informed  SF = Solvent Free  *DPPH Test
4. Conclusions

Obtaining extracts from botanic matrices using novel extraction techniques is increasing, and scientific investigations are progressively focusing on the natural antioxidants which are present in these extracts. Antioxidants have been receiving great attention because they bring benefits to the health and food fields. In this overview, the suitability of using each novel technique for obtaining different antioxidant phytochemicals, based on target compound characteristics, was emphasized.

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REFERENCES

[1] John Shi, Functional Food Ingredients and Nutraceuticals, CRC/Taylor & Francis, Boca Raton (Fla.), 2007.

[2] Z. Djuric, R. K. Severson, I. Kato, "Association of Dietary Quercetin With Reduced Risk of Proximal Colon Cancer", Nutrition and Cancer, vol.64, no.3, pp.351-360, 2012.

[3] P. Karna, S. Chagani, S. R. Gundala, P. C. G. Rida, G. Asif, V. Sharma, M. V. Gupta, R. Aneja, "Benefits of whole Ginger Extract in Prostate Cancer", British Journal of Nutrition, vol.107, no.4, pp.473-484, 2012.

[4] B. J. Xu, S. K. C. Chang, "Comparative Study on Antiproliferation Properties and Cellular Antioxidant Activities of Commonly Consumed Food Legumes Against Nine Human Cancer Cell Lines", Food Chemistry, vol.134, no.3, pp.1287-1296, 2012.

[5] B. Halliwell, "How to characterize a Biological Antioxidant", Free radical research communications, vol.9, no.1, pp.1-32, 1990.

[6] H. J. Bae, G. K. Jayaprakasha, J. Jifon, B. S. Patil, "Variation of Antioxidant Activity and the Levels of Bioactive Compounds in Lipophilic and Hydrophilic Extracts from Hot Pepper (Capsicum spp.) Cultivars", Food Chemistry, vol.134, no.4, pp.1912-1918, 2012.

[7] Ferreidoon Shahidi, Marian Naczk, Phenolics in Food and Nutraceuticals, CRC Press, Boca Raton, 2003.

[8] W. Bors, C. Michel, K. Stettmaier, "Electron Paramagnetic Resonance Studies of Radical Species of Proanthocyanidins and Gallate Esters", Archives of Biochemistry and Biophysics, vol.374, no.2, pp.347-355, 2000.

[9] M. Monica Giusti, Pu Jing, Natural Pigments of Berries: Functionality and Application, In. Berry fruit: value-added products for health promotion, Y Zhao, pp.105-146, CRC Press, Boca Raton, 2007.

[10] H. Van Praag, M. J. Lucero, G. W. Yeo, K. Stecker, N. Heivand, C. Zhao, E. Yip, M. Afaq, H. Schroeter, J. Hammerstone, F. H. Gage, "Plant-Derived Flavanol (-)-Epicatechin Enhances Angiogenesis and Retention of Spatial Memory in Mice", Journal of Neuroscience, vol.27, no.22, pp.5869-5878, 2007.

[11] T. M. Spormann, F. W. Albert, T. Rath, H. Dietrich, F. Will, J. P. Stockis, G. Eisenbrand, C. Janszowski, "Anthocyanin/Polyphenolic-Rich Fruit Juice Reduces Oxidative Cell Damage in an Intervention Study with Patients on Hemodialysis", Cancer Epidemiology Biomarkers and Prevention, vol.17, no.12, pp.3372-3380, 2008.

[12] M. Kamiyama, T. Shibamoto, "Flavonoids with Potent Antioxidant Activity Found in Young Green Barrel Leaves", Journal of Agricultural and Food Chemistry, vol.60, no.25, pp.6260-6267, 2012.

[13] P. Thangavel, R. Muthu, M. Vaiyapuri, "Antioxidant Potential of Narangin - a Dietary Flavonoid - in N-Nitrosodimethylamine Induced Rat Liver Carcinogenesis", Biomedicine and Preventive Nutrition, In Press, 2012.

[14] J. Boateng, M. Verghe,se, "Protective Effects of the Phenolic Extracts of Fruits Against Oxidative Stress in Human Lung Cells", International Journal of Pharmacology, vol.8, no.3, pp.152-160, 2012.

[15] J. A. Joseph, B. Shukitt-Hale, G. J. Brewer, K. A. Weikle, W. Kalt, D. R. Fisher, "Differential Protection Among Fractionated Blueberry Polyphenolic Families Against DA-, Aβ42- and LPS-Induced Declerement in Ca2+ Buffering in Primary Hippocampal Cells", Journal of Agricultural and Food Chemistry, vol.58, no.14, pp.8196-8204, 2010.

[16] R. H. Mohamad, A. M. El-Bastawesy, M. G. Abdel-Monem, A. M. Noor, H. A. R. Al-Mehdad, S. M. Sharawy, M. M. El-Merzabani, "Antioxidant and Anticarcinogenic Effects of Methanolic Extract and Volatile oil of Fennel Seeds (Foeniculum vulgare)", Journal of Medicinal Food, vol.14, no.9, pp.986-1001, 2011.

[17] A. B. Hsouna, M. Saoudi, M. Trigui, K. Jamoussi, T. Boudawara, S. Jaoua, A. E. Feki, "Characterization of Bioactive Compounds and Ameliorative Effects of Ceratonia siliqua Leaf Extract Against CCl4 Induced Hepatic Oxidative Damage and Renal Failure in Rats", Food and Chemical Toxicology, vol.49, no.12, pp.3183-3191, 2011.

[18] M. Nishizawa, T. Haru, T. Miura, S. Fujita, E. Yoshigai, H. Ue, Y. Hayashi, A. H. Kwon, T. Okumura, T. Isaka, "Supplementation with a Flavonol-Rich Lychee Fruit Extract Influences the Inflammatory Status of Young Athletes", Phytotherapy Research, vol.25, no.10, pp.1439-1449, 2011.

[19] M. N. Clifford, "Chlorogenic Acids and Other Cinnamates - Nature, Occurrence and Dietary Burden", Journal of the Science of Food and Agriculture, vol.79, no.3, pp.362-372, 1999.

[20] C. T. Yeh, G. C. Yen, "Induction of Hepatic Antioxidant Enzymes by Phenolic Acids in Rats is Accompanied by Increased Levels of Multidrug Resistance-Associated Protein 3 mRNA Expression", Journal of Nutrition, vol.136, no.1, pp.11-15, 2006.

[21] M. Watabe, K. Hishikawa, A. Takayanagi, N. Shimizu, T. Nakaki, "Caffeic Acid Phenethyl Ester Induces Apoptosis by Inhibition of NFκB and Activation of Fas in Human Breast
Oxidative Stress in Healthy Chinese Middle-aged and Supplementation Protects Erythrocyte Membranes from Y. Sun, A. Ma, Y. Li, X. Han, Q. Wang, H. Liang, "Vitamin E pp.216-223, 2011. Nutritional Science and Vitaminology, vol.57, no.3, IL-8 Expression in Gastric Epithelial AGS Cells", Journal of Y. Kim, J. H. Seo, H. Kim, "beta-Carotene and Lutein Inhibit Hydrogen Peroxide-Induced Activation of NF-Kappa B and IL-8 Expression in Gastric Epithelial AGS Cells", Journal of Biomedical and Biotechnological Research, vol.4, no.16, pp.1686-1694, 2010.

Charles Sell, Chemistry Royal Society of, A fragrant Introduction to Terpenoid Chemistry, Royal Society of Chemistry, Cambridge, 2003.

J. V. Rossolini Jr, G. R. Araújo, B. C. Padua, M. M. Chaves, M. L. Pedrosa, M. E. Silva, D. C. Costa, "Anatto Extract and β-Carotene Modulate the Production of Reactive Oxygen Species/Nitric Oxide in Neutrophils from Diabetic Rats", Journal of Clinical Biochemistry and Nutrition, vol.50, no.3, pp.177-183, 2012.

J. D. Tibodeau, C. R. Isham, K. C. Bible, "Anatto Constituent Cis-Brxin Has Selective Antimyeloma Effects Mediated by Oxidative Stress and Associated with Inhibition of Thioredoxin and Thioredoxin Reductase", Antioxidants and Redox Signaling, vol.13, no.7, pp.987-997, 2010.

P. Palozza, R. Simone, A. Catalano, M. Russo, V. Böhm, "Lycopene Modulation of Molecular Targets Affected by Smoking Exposure", Current Cancer Drug Targets, vol.12, no.6, pp.640-657, 2012.

R. E. Simone, M. Russo, A. Catalano, G. Monego, K. Froehlich, V. Boehm, P. Palozza, "Lycopene Inhibits NF-KB-Mediated IL-8 Expression and Changes Redox and PPARγ Signalling in Cigarette Smoke-Stimulated Macrophages", PLoS ONE, vol.6, no.5, pp.1-11, 2011.

M. Kang, K. S. Park, J. Y. Seo, H. Kim, "Lycopene Inhibits IL-6 Expression in Cerulein-Stimulated Pancreatic Acinar Cells", Genes and Nutrition, vol.6, no.2, pp.117-123, 2011.

V. A. Kirsh, R. B. Hayes, S. T. Mayne, N. Chatterjee, A. F. Subar, L. B. Dixon, D. Albanes, G. L. Andriole, D. A. Urban, U. Peters, Plo Trial, "Supplemental and Dietary Vitamin E, Beta-Carotene, and Vitamin C Intakes and Prostate Cancer Risk", Journal of the National Cancer Institute, vol.98, no.4, pp.245-254, 2006.

Y. Kim, J. H. Seo, H. Kim, "beta-Carotene and Lutein Inhibit Hydrogen Peroxide-Induced Activation of NF-Kappa B and IL-8 Expression in Gastric Epithelial AGS Cells", Journal of Nutritional Science and Vitaminology, vol.57, no.3, pp.216-223, 2011.

Y. Sun, A. Ma, Y. Li, X. Han, Q. Wang, H. Liang, "Vitamin E Supplementation Protects Erythrocyte Membranes from Oxidative Stress in Healthy Chinese Middle-Aged and Elderly People", Nutrition Research, vol.32, no.5, pp.328-334, 2012.

J. Wang, P. Sun, Y. Bao, B. Dou, D. Song, Y. Li, "Vitamin E Renders Protection to PC12 Cells Against Oxidative Damage and Apoptosis Induced by Single-Walled Carbon Nanotubes", Toxicology in Vitro, vol.26, no.1, pp.32-41, 2012.

D. D. Wang, J. Wang, X. H. Huang, Y. Tu, K. Y. Ni, "Identification of Polymethoxylated Flavones from Green Tangerine Peel (Pericarpium Citri Reticulatae Viride) by Chromatographic and Spectroscopic Techniques", Journal of Pharmaceutical and Biomedical Analysis, vol.44, no.1, pp.63-69, 2007.

S. M. Li, T. Lambros, Z. Y. Wang, R. Goodnow, C. T. Ho, "Efficient and Scalable Method in isolation of Polymethoxy flavones from Orange Peel Extract by Supercritical Fluid Chromatography", Journal of Chromatography B, vol.846, no.1-2, pp.291-297, 2007.

M. Skerget, P. Kotnik, M. Hadolin, H. R. Hras, M. Simonic, Z. Knez, "Phenols, Proanthocyanidins, Flavones and Flavonols in Some Plant Materials and their Antioxidant Activities", Food Chemistry, vol.89, no.2, pp.191-198, 2005.
"Characterization and Quantitation of Antioxidant Constituents of Sweet Pepper (Capsicum annuum L."), Journal of Agricultural and Food Chemistry, vol.52, no.12, pp.3861-3869, 2004.

[46] C. Caristi, E. Bellucco, V. Panzera, G. Toscano, R. Vadala, U. Leuzzi, "Flavonoids Detection by HPLC-DAD-MS/MS in Lemon Juices from Sicilian Cultivars", Journal of Agricultural and Food Chemistry, vol.51, no.12, pp. 3528 - 3534, 2003.

[47] A. Valverde-Queralt, O. Jauregui, G. Di Lecce, C. Andres-Laucueva, R. M. Lamuela-Raventos, "Screening of the Polyphenol Content of Tomato-Based Products Through Accurate-Mass Spectrometry (HPLC-ESI-QTOF)", Food Chemistry, vol.129, no.3, pp.877-883, 2011.

[48] M. Bimakr, R. L. A. Rahman, F. S. Taip, A. Ganjoo, L. M. Salleh, J. Selamat, A. Hamid, I. S. M. Zaidul, "Comparison of Different Extraction Methods for the Extraction of Major Bioactive Flavonoid Compounds from Spearmint (Mentha spicata L.) Leaves", Food and Bioproducts Processing, vol.89, pp.67-72, 2011.

[49] S. M. S. Sawalha, D. Arraez-Roman, A. Segura-Carretero, A. Fernandez-Gutierrez, "Quantification of Main Phenolic Compounds in Sweet and Bitter Orange Peel Using CE-MS/MS", Food Chemistry, vol.116, no.2, pp.567-574, 2009.

[50] W. Stuetz, T. Prapamontol, S. Hongibsong, H. K. Biesalski, "Polymethoxylated Flavones, Flavanone Glycosides, Carotenoids, and Antioxidants in Different Cultivation Types of Tangerines (Citrus reticulata Blanco cv. Sainanpueng) from Northern Thailand", Journal of Agricultural and Food Chemistry, vol.58, no.10, pp.6069-6074, 2010.

[51] J. R. Patil, K. N. C. Murthy, G. K. Jayaprakasha, M. B. Chetti, B. S. Patil, "Bioactive Compounds from Mexican Lime (Citrus aurantifolia) Juice Induce Apoptosis in Human Pancreatic Cells", Journal of Agricultural and Food Chemistry, vol.57, no.22, pp.10933-10942, 2009.

[52] A. Raal, A. Orav, T. Püssa, C. Valner, B. Malmiste, E. Arak, "Content of Essential Oil, Terpenoids and Polyphenols in Commercial Chamomile (Chamomilla recutita L. Rauschert) Teas From Different Countries", Food Chemistry, vol.131, no.2, pp.632-638, 2012.

[53] M. A. Rostagno, N. Manchon, M. D’Arrigo, E. Guillamon, A. Villares, A. Garcia-Lafuente, A. Ramos, J. A. Martinez, "Fast and Simultaneous Determination of Phenolic Compounds and Caffeine in Teas, Mate, Instant Coffee, Soft Drink and Energetic Drink by High-Performance Liquid Chromatography Using a Fused-Core Column", Analytica Chimica Acta, vol.685, no.2, pp.204-211, 2011.

[54] E. S. de Brito, M. C. Pessanha de Araújo, L. Z. Lin, J. Hamry, "Determination of the Flavonoid Components of Cashew Apple (Anacardium occidentale) by LC-DAD-ESI/MS", Food Chemistry, vol.105, no.3, pp.1112-1118, 2007.

[55] S. F. Reis, D. K. Rai, N. Abu-Ghannam, "Water at Room Temperature as a Solvent for the Extraction of Apple Pomace Phenolic Compounds", Food Chemistry, vol.135, no.3, pp.1991-1998, 2012.

[56] K. Aaby, S. Mazur, A. Nes, G. Skrede, “Phenolic Compounds in Strawberry (Fragaria x ananassa Duch.) Fruits: Composition in 27 Cultivars and Changes During Ripening”, Food Chemistry, vol.132, no.1, pp.86-97, 2012.

[57] M. Dehkargarhanian, H. Adenier, M. A. Vijayalakshmi, "Study of Flavonoids in Aqueous Spinach Extract Using Positive Electrospray Ionisation Tandem Quadrupole Mass Spectrometry", Food Chemistry, vol.121, no.3, pp.863-870, 2010.

[58] R. Perestrello, Y. Lu, S. A. O. Santos, A. J. D. Silvestre, C. P. Neto, J. S. Camara, S. M. Rocha, "Phenolic Profile of Sercial and Tinta Negra Vitis vinifera L. Grape Skins by HPLC-DAD-ESI-MS n: Novel Phenolic Compounds in Vitis vinifera L. grape", Food Chemistry, vol.135, no.1, pp.94-104, 2012.

[59] R. Bobinait, P. Viškelis, P. R. Venskutonis, "Variation of Total Phenolics, Anthocyanins, Ellagic Acid and Radical Scavenging Capacity in Various Raspberry (Rubus spp.) Cultivars", Food Chemistry, vol.132, no.3, pp.1495-1501, 2012.

[60] I. Damar, A. Ekşi, "Antioxidant Capacity and Anthocyanin Profile of Sour Cherry (Prunus cerasus L.) Juice", Food Chemistry, vol.135, no.4, pp.2910-2914, 2012.

[61] Diego T. Santos, Priscilla C. Veggi, M. Angela A. Meireles, "Extraction of Antioxidant Compounds from Jabuticaba (Myrciaria cauliflora) Skins: Yield, Composition and Economical Evaluation", Journal of Food Engineering, vol.101, no.1, pp.23-31, 2010.

[62] E. Sentandreu, J. L. Navarro, J. M. Sendra, "Identification of New Coloured Anthocyanin-Flavanol Adducts in Pressure-Extracted Pomegranate (Punica granatum L.) Juice by High-Performance Liquid Chromatography/Electrospray Ionization Mass Spectrometry", Food Analytical Methods, vol.5, no.4, pp.702-709, 2012.

[63] Y. Wang, X. L. Chen, Y. M. Zhang, X. S. Chen, "Antioxidant Activities and Major Anthocyanins of Myrobalan Plum (Prunus cerasifera Ehrh.)", Journal of Food Science, vol.77, no.4, pp.C388-C393, 2012.

[64] M. J. Payne, W. J. Hurst, C. Rank, D. A. Stuart, "Impact of Fermentation, Drying, Roasting, and Dutch Processing on Epicatechin and Catechin Content of Cacao Beans and Cocoa Ingredients", Journal of Agricultural and Food Chemistry, vol.57, no.4, pp.C388-C393, 2009.

[65] M. G. Dias, M. F. G. F. C. Camões, L. Oliveira, "Carotenoids in Traditional Portuguese Fruits and Vegetables", Food Chemistry, vol.113, no.3, pp.808-815, 2009.

[66] C. Kurz, R. Carle, A. Schieber, "HPLC-DAD-MSn Characterisation of Carotenoids from Apricots and Pumpkins for the Evaluation of Fruit Product Authenticity", Food Chemistry, vol.110, no.2, pp.522-530, 2008.

[67] L. E. Gayosos-Garcia Sancho, E. M. Yahia, G. A. González-Aguilar, "Identification and Quantification of Phenols, Carotenoids, and Vitamin C from Papaya (Carica papaya L. cv. Maradol) Fruit Determined by HPLC-DAD-MS/MS-ESI", Food Research International, vol.44, no.5, pp.1284-1291, 2011.
[69] C. H. Azevedo - Meleiro, D. B. Rodriguez - Amaya, "Qualitative and Quantitative Differences in Carotenoid Composition Among Cucurbita moschata, Cucurbita maxima, and Cucurbita pepo", Journal of Agricultural and Food Chemistry, vol.55, no.10, pp.4027-4033, 2007.

[70] D. B. Rodriguez-Amaya, M. Kimura, H. T. Godoy, J. Amaya-Farfan, "Updated Brazilian Database on Food Carotenoids: Factors Affecting Carotenoid Composition", Journal of Food Composition and Analysis, vol.21, no.6, pp.445-463, 2008.

[71] H. Ashrafi, M. P. Kinkade, H. L. Merk, M. R. Foolad, "Identification of Novel Quantitative Trait Loci for Increased Lycopene Content and Other Fruit Quality Traits in a Tomato Recombinant Inbred Line Population", Molecular Breeding, vol.30, no.1, pp.549-567, 2012.

[72] R. M. Schweiggert, C. B. Steinbass, A. Heller, P. Esquivel, R. Carle, "Characterization of Chromoplasts and Carotenoids of Red- and Yellow-Fleshed Papaya (Carica papaya L.)", Planta, vol.234, no.5, pp.1031-1044, 2011.

[73] I. Tili, C. Hildaer, M. S. Lenucci, I. Riadh, H. Jebari, G. Dalessandro,"Bioactive Compounds and Antioxidant Activities of Different Watermelon (Citullus lanatus (Thunb.) Mansfeld) Cultivars as Affected by Fruit Sampling Area", Journal of Food Composition and Analysis, vol.24, no.3, pp.307-314, 2011.

[74] K. W. Kong, A. Ismail, "Lycopene Content and Lipophilic Antioxidant Capacity of By-Products from Psidium guajava Fruits Produced During Puree Production Industry", Food and Bioproducts Processing, vol.89, no.C1, pp.53-61, 2011.

[75] L. Del Moral, J. M. Fernandez-Martinez, B. Perez-Vich, L. Velasco, "Expression of Modified Tocopherol Content and Profile in Sunflower Tissues", Journal of the Science of Food and Agriculture, vol.92, no.2, pp.351-357, 2012.

[76] J. Chun, J. Lee, R. R. Eitenmiller, "Vitamin E and Oxidative Stability During Storage of Raw and Dry Roasted Peanuts Packaged Under Air and Vacuum", Journal of Food Science, vol.70, no.4, pp.C292-C297, 2005.

[77] Y. Y. Lee, H. M. Park, C. K. Lee, S. L. Kim, T. Y. Hwang, M. S. Choi, Y. U. Kwon, W. H. Kim, S. J. Kim, S. C. Lee, Y. H. Kim, "Comparing Extraction Methods for the Determination of Tocopherols and Tocotrienols in Seeds and Germinating Seeds of Soybean Transformed with OsHGGT", Journal of Food Composition and Analysis, vol.27, no.1, pp.70-80, 2012.

[78] W. W. Ren, L. X. Zhao, Y. L. Wang, L. J. Cui, Y. L. Tang, X. F. Sun, K. X. Tang, "Overexpression of Homogenisate Phytyltransferase in Lettuce Results in Increased Content of Vitamin E", African Journal of Biotechnology, vol.10, no.64, pp.14046-14051, 2011.

[79] Z. W. Sheng, W. H. Ma, Z. Q. Jin, Y. Bi, Z. G. Sun, H. T. Dou, J. H. Gao, J. Y. Li, L. N. Han, "Investigation of Dietary Fiber, Protein, Vitamin E and Other Nutritional Compounds of Banana Flower of Two Cultivars Grown in China", African Journal of Biotechnology, vol.9, no.25, pp.3888-3895, 2010.

[80] L. Jakobek, M. Seruga, S. Voca, Z. Sindrak, N. Dobricevic, "Flavonol and Phenolic Acid Composition of Sweet Cherries (cv. Lapins) Produced on Six Different Vegetative Rootstocks", Scientia Horticulturae, vol.123, no.1, pp.23-28, 2009.

[81] N. J. Kang, K. W. Lee, B. J. Shin, S. K. Jung, M. K. Hwang, A. M. Bode, Y. S. Heo, H. J. Lee, Z. G. Dong, "Caffeic Acid, a Phenolic Phytochemical in Coffee, Directly Inhibits Fyn Kinase Activity and UVB-Induced COX-2 Expression", Carcinogenesis, vol.30, no.2, pp.321-330, 2009.

[82] R. Horax, N. Hettiarachchy, S. Islam, "Total Phenolic Contents and Phenolic Acid Constituents in 4 Varieties of Bitter Melons (Momordica charantia) and Antioxidant Activities of their Extracts", Journal of Food Science, vol.70, no.4, pp.C275-C280, 2005.

[83] Stanley T. Omuye, Food and Nutritional Toxicology, CRC Press, Boca Raton-FL, 2004.

[84] R. C. Lindenschmidt, A. F. Tryka, M. E. Goad, H. P. Witschi, "The Effects of Dietary Butylated Hydroxytoluene on Liver and Colon-Tumor Development in Mice", Toxicology, vol.38, no.2, pp.151-160, 1986.

[85] K. M. Káková, The Regulation of Antioxidants in Food, Vol. 2, In. Food Chemical Safety, DH Watson, pp.267-283, CRC Press; Woodhead, Boca Raton, Fl.; Cambridge, 2002.

[86] Henry I. Castro-Vargas, Luis I. Rodriguez-Varela, Sandra R. S. Ferreia, Fabián Parada-Alfonso, "Extraction of Phenolic Fraction from Guava Seeds (Psidium guajava L) Using Supercritical Carbon Dioxide and Co-Solvents", Journal of Supercritical Fluids, vol.51, no.3, pp.319-324, 2010.

[87] Chin-Hui Chen, Tsuey-Pin Lin, Yu-Ling Chung, Ching-Kuo Lee, Dong-Bor Yeh, Shih-Ying Chen, "Determination of Antioxidative Properties of Morinda citrifolia Using Near Supercritical Fluid Extraction", Journal of Food and Drug Analysis, vol.17, no.5, pp.333-341, 2009.

[88] Michelle Co, Amelie Fagerlund, Lars Engman, Kerstin Tannerheim, Per J. R. Sjoberg, Charlotta Turner, "Extraction of Antioxidants from Spruce (Picea abies) Bark Using Eco-Friendly Solvents", Phytochemical Analysis, vol.23, no.1, pp.1-11, 2012.

[89] Gonzalo Vicente, Mónica R. Garcia-Risco, Tiziana Fornari, Guillermo Reglero, "Supercritical Fractionation of Rosemary Extracts to Improve the Antioxidant Activity", Chemical Engineering & Technology, vol.35, no.1, pp.176-182, 2012.

[90] H. H. Wijngaard, M. Ballay, N. Brunton, "The Optimisation of Extraction of Antioxidants from Potato Peel by Pressurised Liquids", Food Chemistry, vol.133, no.4, pp.1123-1130, 2012.

[91] Le Ying, Ping Xu, Shangru Huang, Yuefei Wang, "Antioxidant Activity of Bioactive Compounds Extracted from Ampelopsis grossedentata Leaves by Optimized Supercritical Carbon Dioxide", Journal of Medicinal Plants Research, vol.5, no.17, pp.4373-4381, 2011.

[92] Hee-Ock Boo, Sung-Jin Hwang, Chun-Sik Bae, Su-Hyun Park, Bok-Gu Heo, Shela Gorinstein, "Extraction and Characterization of Some Natural Plant Pigments", Industrial Crops and Products, vol.40, pp.129-135, 2012.

[93] Monika A. Olszewska, Anna Presler, Piotr Michel, "Profiling of Phenolic Compounds and Antioxidant Activity of Dry Extracts from the Selected Sorbus Species", Molecules, vol.17, no.3, pp.3093-3113, 2012.

[94] Kanti Bhosshan Pandey, Syed Ibrahim Rizvi, "Plant Polyphenols as Dietary Antioxidants in Human Health and
Disease”, Oxidative Medicine and Cellular Longevity, vol.2, no.5, pp.270-278, 2009.

[95] F. Agostini, R. A. Bertussi, G. Agostini, A. C. Atti dos Santos, M. Rossato, R. Vanderlinde, "Supercritical Extraction from Vinification Residues: Fatty Acids, Alpha-Tocopherol, and Phenolic Compounds in the Oil Seeds from Different Varieties of Grape", The Scientific World Journal, pp.1-9, 2012.

[96] Kátia S. Andrade, Ricardo T. Gonçalvez, Marcelo Maraschin, Rosa Maria Ribeiro-do-Valle, Julian Martinez, Sandra R. S. Ferreira, "Supercritical Fluid Extraction from Spent Coffee Grounds and Coffee Husks: Antioxidant Activity and Effect of Operational Variables on Extract Composition", Talanta, vol.88, pp.544-552, 2012.

[97] Claudia P. Passos, Rui M. Silva, Francisco A. Da Silva, Manuel A. Coimbra, Carlos M. Silva, "Supercritical Fluid Extraction of Grape Seed (Vitis vinifera L.) Oil. Effect of the Operating Conditions Upon Oil Composition and Antioxidant Capacity", Chemical Engineering Journal, vol.160, no.2, pp.634-640, 2010.

[98] A. S. Zarena, K. Udaya Sankar, "Supercritical Carbon Dioxide Extraction of Xanthones with Antioxidant Activity from Garcinia mangostana: Characterization by HPLC/ LC-ESI -MS", Journal of Supercritical Fluids, vol.49, no.3, pp.330-337, 2009.

[99] M. Cam, Y. Hisil, "Pressurised Water Extraction of Polyphenols from Pomegranate Peels", Food Chemistry, vol.123, no.3, pp.878-885, 2010.

[100] S. Erdogan, B. Ates, G. Durmaz, I. Yilmaz, T. Seckin, "Pressurized Liquid Extraction of Phenolic Compounds from Anatolia Propolis and their Radical Scavenging Capacities", Food and Chemical Toxicology, vol.49, no.7, pp.1592-1597, 2011.

[101] Hongyan Li, Zeyuan Deng, Tao Wu, Ronghua Liu, Steven Loewen, Rong Tsao, "Microwave-Assisted Extraction of Phenolics with Maximal Antioxidant Activities in Tomatoes", Food Chemistry, vol.130, no.4, pp.928-936, 2012.

[102] Sandrine Perino-Issartier, Huma Zill e, Maryline Abert-Vian, Farid Chemat, "Solvent Free Microwave-Assisted Extraction of Antioxidants from Sea Buckthorn (Hippophae rhamnoides) Food By-Products", Food and Bioprocess Technology, vol.4, no.6, pp.1020-1028, 2011.

[103] Meric Simsek, Gulum Sumnu, Serpil Sahin, "Microwave Assisted Extraction of Phenolic Compounds from Sour Cherry Pomace", Separation Science and Technology, vol.47, no.8, pp.1248-1254, 2012.

[104] Jie Bi, Qingdi Yang, Jie Sun, Jian Chen, Juan Zhang, "Study on Ultrasonic Extraction Technology and Oxidation Resistance of Total Flavonoids from Peanut Hull", Food Science and Technology Research, vol.17, no.3, pp.187-198, 2011.

[105] Kashif Ghafoor, Teng Hui, Yong Hee Choi, "Optimization of Ultrasonic-Assisted Extraction of Total Anthocyanins from Grape Peel Using Response Surface Methodology", Journal of Food Biochemistry, vol.35, no.3, pp.735-746, 2011.

[106] E. Vági, B. Simándi, K. P. Vásárhelyi iné, H. Daoed, A. Kéry, F. Doleschall, B. Nagy, "Supercritical Carbon Dioxide Extraction of Carotenoids, Tocopherols and Sitosterols from Industrial Tomato By-Products", Journal of Supercritical Fluids, vol.40, no.2, pp.218-226, 2007.

[107] J. K. Monrad, L. R. Howard, J. W. King, K. Srinivas, A. Mauromoustakos, "Supercritical Solvent Extraction of Anthocyanins from Dried Red Grape Pomace", Journal of Agricultural and Food Chemistry, vol.58, no.5, pp.2862-2868, 2010.

[108] B. Aliakbarian, A. Fathi, P. Perego, F. Dehghani, "Extraction of Antioxidants from Winery Wastes Using Subcritical Water", Journal of Supercritical Fluids, vol.65, pp.18-24, 2012.

[109] Thaís M. Takeuchi, Camila G. Pereira, Mara E. M. Braga, Mário R. Maróstica, Patrícia F. Leal, Maria Angela A. Meireles, Low-Pressure Solvent Extraction (Solid-Liquid Extraction, Microwave Assisted and Ultrasound Assisted) from Condomintary Plants, In. Extracting bioactive compounds for food products: theory and applications, MAA Meireles, pp.137-218, CRC Press, Boca Raton, 2009.

[110] M. A. Rosstago, M. Palma, C. G. Barroso, "Ultrasound - Assisted Extraction of Soy Isoflavones", Journal of Chromatography A, vol.1012, no.2, pp.119-128, 2003.

[111] K. Zosel, Process for Recovering Caffeine, US 3806619, Oberhausen/Rheinland (DE), 1974.

[112] K. Zosel, Process for the Decaffeination of Coffee, US 4247570, Oberhausen (DE), 1981.

[113] D. Chou, Y. Wu, L. Wang, Preparing Carotenoid Microcapsules with a Controllable Isometric Ratio, Comprises Separating Carotenoids in Chromatographic Column, Washing with a Mobile Phase, and Adding Stationary Phase after Absorbing Isomer into a High Pressure Kettle, CN101879428-A, Kajang (MY), 2012.

[114] C. Y. May, M. A. Ngan, Y. Basiron, D. Y. Basiron, A. N. Ma, Y. M. Choo, D. D. Y. Basiron, Isolation of Vitamin E isomers from Tocots Useful as a Nutritional Antioxidant Involves the use of the Supercritical Fluid in the Adsorption/Desorption Chromatography, EP1122250-A, Kajang (MY), 2003.

[115] J. Chen, K. Yang, S. Chen, T. Adschiri, K. Arai, "Effects of Ultrasound on Mass Transfer in Supercritical Extraction", in The 4th International Symposium on Supercritical Fluids, Sendai (JA), 1997.

[116] Yanxiang Gao, Bence Nagy, Xuan Liu, Béla Simándi, Qi Wang, "Supercritical CO2 Extraction of Lutein Esters from Marigold (Tagetes erecta L.) Enhanced by Ultrasound", The Journal of Supercritical Fluids, vol.49, no.3, pp.345-350, 2009.

[117] Ai-jun Hu, Shuana Zhao, Hanhua Liang, Tai-gui Qiu, Guohua Chen, "Ultrasound Assisted Supercritical Fluid Extraction of Oil and Coixenolide from Adlay Seed", Ultrasones Sonochemistry, vol.14, no.2, pp.219-224, 2007.

[118] Beatriz Diaz-Reinoso, Andrés Moure, Herminia Domínguez, Juan Carlos Parajó, Antioxidant Extraction by Supercritical Fluids, In. Supercritical Fluid Extraction of Nutraceuticals and Bioactive Compounds, JL Martinez, pp.275-303, CRC Press, Boca Raton, FL, 2008.

[119] Beatriz Diaz-Reinoso, A. Moure, H. Domínguez, J. C. Parajó, "Supercritical CO2 Extraction and Purification of Compound s with Antioxidant Activity", Journal of Agricultural and Food Chemistry, vol.54, no.7, pp.2441-2469, 2006.
[120] Paulo T. V. Rosa, M. A. A. Meireles, Supercritical and Pressurized Fluid Extraction: Theory and Applications, MAA Meireles, pp.269-401, CRC Press, Boca Raton, FL, 2009.

[121] C. F. Ku, J. D. Su, C. H. Chiu, C. C. Peng, C. H. Chang, T. Y. Sung, S. H. Huang, W. C. Lee, C. C. Chyau, "Anti-Inflammatory Effects of Supercritical Carbon Dioxide Extract and its Isolated Carnosic Acid from Rosmarinus officinalis Leaves", Journal of Agricultural and Food Chemistry, vol.59, no.8, pp.3674-3685, 2011.

[122] Priscilla P. Almeida, Natália Mezzomo, Sandra R. S. Ferreira, "Extraction of Mentha spicata L. Volatile Compounds: Evaluation of Process Parameters and Extract Composition", Food and Bioprocess Technology, vol.5, no.2, pp.548-559, 2012.

[123] B. Mandana, A. R. Russly, G. Ali, S. T. Farah, "Antioxidant Activity of Spearmint (Mentha spicata L.) Leaves Extracts by Supercritical Carbon Dioxide (SC-CO2) Extraction", International Food Research Journal, vol.18, no.2, 2011.

[124] Yuefei Wang, Da Sun, Hao Chen, Lisheng Qian, Ping Xu, "Fatty Acid Composition and Antioxidant Activity of Tea (Camellia sinensis L.) Seed Oil Extracted by Optimized Supercritical Carbon Dioxide", International Journal of Molecular Sciences, vol.12, no.11, pp.7708-7719, 2011.

[125] Clara Grosso, Ana Cristina Figueiredo, Jesus Burillo, Ana M. Mainar, José S. Urieta, José G. Barroso, José A. Coelho, António M. F. Palavra, "Composition and Antioxidant Activity of Thymus vulgaris Volatiles: Comparison Between Supercritical Fluid Extraction and Hydrodistillation", Journal of Separation Science, vol.33, no.14, pp.2211-2218, 2010.

[126] Patricia Benelli, Carlos A. S. Riehl, Artur Smânia, Jr, Elza F. A. Smânia, Sandra R. S. Ferreira, "Bioactive Extracts of Orange (Citrus sinensis L. Osbeck) Pomace Obtained by SFE and Low Pressure Techniques: Mathematical Modeling and Extract Composition", Journal of Supercritical Fluids, vol.55, no.1, pp.132-141, 2010.

[127] Chi-Huang Chang, Ching-Cheng Chyau, Chiu-Lan Hsieh, Yen-Ying Wu, Yaw-Bee Ker, Hau-Yang Tsen, Robert Y. Peng, "Relevance of Phenolic Diterpene Constituents to Antioxidant Activity of Supercritical CO2 Extract from the Leaves of Rosemary", Natural Product Research, vol.22, no.1, pp.76-90, 2008.

[128] F. P. Lucien, N. R. Foster, "Solubilities of Solid Mixtures in Supercritical Carbon Dioxide: A Review", Journal of Supercritical Fluids, vol.17, no.2, pp.111-134, 2000.

[129] G. Vicente, S. Molina, M. González-Vallinas, M. R. García-Risco, T. Fornari, G. Reglero, A. R. de Molina, "Supercritical Rosemary Extracts, their Antioxidant Activity and Effect on Hepatic Tumor Progression", In Press, Journal of Supercritical Fluids, 2012.

[130] M. Hamburger, D. Baumann, S. Adler, "Supercritical Carbon Dioxide Extraction of Selected Medicinal Plants - Effects of High Pressure and Added Ethanol on Yield of Extracted Substances", Phytochemical Analysis, vol.15, no.1, pp.46-54, 2004.

[131] Patricia F. Leal, Nilson B. Maia, Quirino A. C. Carmello, Rodrigo R. Catharino, Marcos N. Eberlin, M. Angela A. Meireles, "Sweet Basil (Ocimum basilicum) Extracts Obtained by Supercritical Fluid Extraction (SFE): Global Yields, Chemical Composition, Antioxidant Activity, and Estimation of the Cost of Manufacturing", Food and Bioprocess Technology, vol.1, no.4, pp.326-338, 2008.

[132] L. Casas, C. Mantell, M. Rodriguez, A. Torres, F. A. Macias, E. Martinez de la Ossa, "Effect of the Addition of Cosolvent on the Supercritical Fluid Extraction of Bioactive Compounds from Helianthus annuus L", Journal of Supercritical Fluids, vol.41, no.1, pp.43-49, 2007.

[133] P. García-Salas, A. Morales-Soto, A. Segura-Carretero, A. Fernández-Gutiérrez, "Phenolic-Compound-Extraction Systems for Fruit and Vegetable Samples", Molecules, vol.15, no.12, pp.8813-8826, 2010.

[134] S. D. Yeo, S. J. Park, J. W. Kim, J. C. Kim, "Critical Properties of Carbon Dioxide plus Methanol, plus Ethanol, +1-Propanol, and +1-Butanol", Journal of Chemical and Engineering Data, vol.45, no.5, pp.932-935, 2000.

[135] Juliana M. Prado, Priscilla Carvalho Veggi, M. Angela A. Meireles, "Extraction Methods for Obtaining Carotenoids from Vegetables", Current Analytical Chemistry, vol. In press, 2013.

[136] Y. N. Lee, C. R. Chen, H. L. Yang, C. C. Lin, C. M. J. Chang, "Isolation and Purification of 3,5-Diphenyl - 4 - Hydroxy cinnamic Acid (Artepillin C) in Brazilian Propolis by Supercritical Fluid Extractions", Separation and Purification Technology, vol.54, no.1, pp.130-138, 2007.

[137] J. D. C. Francisco, B. Danielsson, A. Kazubeck, E. S. Dey, "Extraction of Rye Bran by Supercritical Carbon Dioxide: Influence of Temperature, CO2, and Cosolvent Flow Rates", Journal of Agricultural and Food Chemistry, vol.53, no.19, pp.7432-7437, 2005.

[138] John Shi, Chun Yi, Sophia Jun Xue, Yueming Jiang, Ying Ma, Dong Li, "Effects of Modifiers on the Profile of Lycopene Extracted from Tomato Skins by Supercritical CO2", Journal of Food Engineering, vol.93, no.4, pp.431-436, 2009.

[139] M. San, F. Temelli, "Supercritical Carbon Dioxide Extraction of Carotenoids from Carrot Using Canola Oil as a Continuous Co-Solvent", Journal of Supercritical Fluids, vol.37, no.3, pp.397-408, 2006.

[140] Feliciano Priego-Capote, María Del Pilar Delgado De La Torre, Accelerated Liquid Extraction, In. Natural Product Engineering Data, vol.45, no.5, pp.932-935, 2000.

[141] W. Li, Z. Wang, Y. P. Wang, C. Jiang, Q. Liu, Y. S. Sun, Y. N. Zheng, "Pressurised Liquid Extraction Combining LC-DAD -ESI/MS Analysis as an Alternative Method to Extract Three Major Flavones in Citrus reticulata 'Chachi' (Guangchenpi)", Food Chemistry, vol.130, no.4, pp.1044-1049, 2012.

[142] P. Budrat, A. Shotipruk, "Enhanced Recovery of Phenolic Compounds from Bitter Melon (Momordica charantia) by Subcritical Water Extraction", Separation and Purification Technology, vol.66, no.1, pp.125-129, 2009.

[143] C. I. Cheigh, E. Y. Chung, M. S. Chung, "Enhanced Extraction of Flavanones Hesperidin and Narirutin from Citrus unshiu Peel Using Subcritical Water", Journal of Food Engineering, vol.110, no.3, pp.472-477, 2012.

[144] L. St' avikova, M. Polovka, B. Hohnova, P. Karasek, M. Roth, "Antioxidant Activity of Grape Skin Aqueous Extracts from Pressurized Hot Water Extraction Combined with Electron
Paramagnetic Resonance Spectroscopy", Talanta, vol. 85, no. 4, pp. 2233-2240, 2011.

[145] J. W. King, R. D. Grabiel, Isolation of Polyphenolic Compounds from Fruits or Vegetable Utilizing Sub-Critical Water Extraction, US7208181-B1, Washington, DC (USA), 2007.

[146] J. M. Luque-Rodriguez, M. D. Luque de Castro, P. Perez-Juan, "Dynamic Superheated Liquid Extraction of Anthocyanins and other Phenolics from Red Grape Skins of Winemaking Residues", Biotechnology and Bioprocess Engineering, vol. 98, no. 14, pp. 2705-2713, 2007.

[147] J. E. Cacace, G. Mazza, "Mass Transfer Process During Extraction of Phenolic Compounds from Milled Berries", Journal of Food Engineering, vol. 59, no. 4, pp. 379-389, 2003.

[148] A. Kirca, M. Özkan, B. Cemeroğlu, "Effects of Temperature, Solid Content and pH on the Stability of Black Carrot Anthocyanins", Food Chemistry, vol. 101, no. 1, pp. 212-218, 2006.

[149] T. L. Miron, M. Plaza, G. Bahrim, E. Ibáñez, M. Herrero, "Chemical Composition of Bioactive Pressurized Extracts of Romanian Aromatic Plants", Journal of Chromatography A, vol. 1218, no. 30, pp. 4918-4927, 2011.

[150] D. T. Santos, P. C. Veggi, M. A. A. Meireles, "Optimization and Economic Evaluation of Pressurized Liquid Extraction of Phenolic Compounds from Jabuticaba Skins", Journal of Food Engineering, vol. 108, no. 3, pp. 444-452, 2012.

[151] G. Garrote, H. Domínguez, J. C. Parajo, "Production of Substituted Oligosaccharides by Hydrolytic Processing of Barley Husks", Industrial and Engineering Chemistry Research, vol. 43, no. 7, pp. 1608-1614, 2004.

[152] A. Moure, H. Domínguez, J. C. Parajo, "Antioxidant Activity of Liquors from Aqueous Treatments of Pinus radiata Wood", Wood Science and Technology, vol. 39, no. 2, pp. 129-139, 2005.

[153] A. Mustafa, C. Turner, "Pressurized Liquid Extraction as a Green Approach in Food and Herbal Plants Extraction: A Review", Analytica Chimica Acta, vol. 703, no. 1, pp. 8-18, 2011.

[154] S. Rodriguez-Rojo, A. Visentin, D. Maestri, M. J. Cocero, "Assisted Extraction of Rosemary Antioxidants with Green Solvents", Journal of Food Engineering, vol. 109, no. 1, pp. 98-103, 2012.

[155] Zill-e Huma, Maryline Abert Vian, Anne-Sylvie Fabiano-Tixier, Mohamed Elmaataoui, Olivier Dangles, Farid Chemat, "A Remarkable Influence of Microwave Extraction: Enhancement of Antioxidant Activity of Extracted Onion Varieties", Food Chemistry, vol. 127, no. 4, pp. 1472-1480, 2011.

[156] Xueling Zheng, Benguo Liu, Limin Li, Xiaohui Zhu, "Microwave-Assisted Extraction and Antioxidant Activity of Total Phenolic Compounds From Pomegranate Peel", Journal of Medicinal Plants Research, vol. 5, no. 6, pp. 1004-1011, 2011.

[157] Tameshia S. Ballard, Parmeswara Kamalarathna Mallikarjunan, Kequan Zhou, Sean O’Keefe, "Microwave - Assisted Extraction of Phenolic Antioxidant Compounds from Peanut Skins", Food Chemistry, vol. 120, no. 4, pp. 1185-1192, 2010.
Oleoresin with CO2 and Co-Solvents: A Study of the

K. C. Zancan, M. O. M. Marques, A. J. Petenate, M. A. A. Meireles, "Extraction of Ginger (Zingiber officinale roscoe) Oleoresin with CO2 and Co-Solvents: A Study of the Antioxidant Action of the Extracts", Journal of Supercritical Fluids, vol.24, no.1, pp.57-76, 2001.

L. F. De França, G. Reber, M. A. A. Meireles, N. T. Machado, G. Brunner, "Supercritical Extraction of Carotenoids and Lipids from Buriti (Mauritia flexuosa), a Fruit from the Amazon Region", Journal of Supercritical Fluids, vol.14, no.3, pp.247-256, 1999.

G. L. Filho, V. V. De Rosso, M. A. A. Meireles, P. T. V. Rosa, A. L. Oliveira, A. Z. Mercadante, F. A. Cabral, "Supercritical CO2 Extraction of Carotenoids from Pitanga Fruits (Eugenia uniflora L.)", Journal of Supercritical Fluids, vol.46, no.1, pp.33-39, 2008.

M. Polovka, L. Šťavíková, B. Hohnová, P. Karásek, M. Roth, "Offline Combination of Pressurized Fluid Extraction and Electron Paramagnetic Resonance Spectroscopy for Antioxidant Activity of Grape Skin Extracts Assessment", Journal of Chromatography A, vol.1217, no.51, pp.7990-8000, 2010.

L. Howard, N. Pandjaitan, "Pressurized Liquid Extraction of Flavonoids from Spinach", Journal of Food Science, vol.73, no.3, pp.C151-C157, 2008.

D. L. Luthria, "Optimization of Extraction of Phenolic Acids from a Vegetable Waste Product Using a Pressurized Liquid Extractor", Journal of Functional Foods, no.4, pp.842-850, 2012.

P. Dobiáš, P. Pavlíková, M. Adam, A. Eisner, B. Beňová, K. Ventura, "Comparison of Pressurised Fluid and Ultrasound Extraction Methods for Analysis of Plant Antioxidants and their Antioxidant Capacity", Central European Journal of Chemistry, vol.8, no.1, pp.87-95, 2010.

H. Wijnegard, N. Brunton, "The Optimization of Extraction of Antioxidants from Apple Pomace by Pressurized Liquids", Journal of Agricultural and Food Chemistry, vol.57, no.22, pp.10625-10631, 2009.

S. Jokić, M. Cvjetko, D. Božić, S. Fabek, N. Toth, J. Vorkapić-Furač, I. R. Redovniković, "Optimisation of Microwave-Assisted Extraction of Phenolic Compounds from Broccoli and its Antioxidant Activity", International Journal of Food Science and Technology, 2012.

K. Krishnaswamy, V. Onsat, V. Gariépy, K. Thangavel, "Optimization of Microwave-Assisted Extraction of Phenolic Antioxidants from Grape Seeds (Vitis vinifera)", Food and Bioprocess Technology, pp.1-15, 2012.

Monica Gallo, Rosalia Ferracane, Giulia Graziani, Alberto Ritiemi, Vincenzo Fogliano, "Microwave Assisted Extraction of Phenolic Compounds from Four Different Spices", Molecules, vol.15, no.9, pp.6365-6374, 2010.

R. Tabarak, E. Heidarizadi, A. Benvidi, "Optimization of Ultrasound-Assisted Extraction of Pomegranate (Punica granatum L.) Peel Antioxidants by Response Surface Methodology", Separation and Purification Technology, vol.98, pp.16-23, 2012.

M. B. Hassain, N. P. Brunton, A. Patras, B. Tiwari, C. P. O'Donnell, A. B. Martin-Diana, C. Barry-Ryan, "Optimization of Ultrasound Assisted Extraction of Antioxidant Compounds from Marjoram (Origanum majorana L.) Using Response Surface Methodology", Ultrasounds Sonochemistry, vol.19, no.3, pp.582-590, 2012.
[196] H. V. Annegowda, R. Bhat, L. Min-Tze, A. A. Karim, S. M. Mansor, "Influence of Sonication Treatments and Extraction Solvents on the Phenolics and Antioxidants in Star Fruits", Journal of Food Science and Technology, vol.49, no.4, pp.510-514, 2012.

[197] H. V. Le, V. M. L. Van, "Comparison of Enzyme-Assisted and Ultrasound-Assisted Extraction of Vitamin C and Phenolic Compounds from Acerola (Malpighia emarginata DC.) Fruit", International Journal of Food Science and Technology, vol.47, no.6, pp.1206-1214, 2012.

[198] X. Jun, Z. Shuo, L. Bingbing, Z. Rui, L. Ye, S. Deji, Z. Guofeng, "Separation of major catechins from green tea by ultrahigh pressure extraction", International Journal of Pharmaceutics, vol.386, no.1-2, pp.229-231, 2010.

[199] Yu-Wen Hsu, Chia-Fang Tsai, Wen-Kang Chen, Yung-Chyuan Ho, Fung-Jou Lu, "Determination of Lutein and Zeaxanthin and Antioxidant Capacity of Supercritical Carbon Dioxide Extract from Daylily (Hemerocallis disticha)", Food Chemistry, vol.129, no.4, pp.1813-1818, 2011.

[200] Wei Xu, Kedan Chu, Huang Li, Lidian Chen, Yuqin Zhang, Xuchong Tang, "Extraction of Lepidium apetalum Seed Oil Using Supercritical Carbon Dioxide and Anti-Oxidant Activity of the Extracted Oil", Molecules, vol.16, no.12, pp.10029-10045, 2011.

[201] Mohd Sabri Pak-Dek, Azizah Osman, Najla Gooda Sahib, Nazanid Anwar, Masturah Markom, Azizah Abdul Hamid, Farooq Anwar, "Effects of Extraction Techniques on Phenolic Components and Antioxidant Activity of Mengkuudu (Morinda citrifolia L.) Leaf Extracts", Journal of Medicinal Plants Research, vol.5, no.20, pp.5050-5057, 2011.

[202] Mi-Bo Kim, Jae-Sung Park, Sang-Bin Lim, "Antioxidant Activity and Cell Toxicity of Pressurised Liquid Extracts from 20 Selected Plant Species in Jeju, Korea", Food Chemistry, vol.122, no.3, pp.546-552, 2010.

[203] Ying Xie, Jinyong Peng, Guorong Fan, Yutian Wu, "Chemical Composition and Antioxidant Activity of Volatiles from Patania Villosa Juss Obtained by Optimized Supercritical Fluid Extraction", Journal of Pharmaceutical and Biomedical Analysis, vol.48, no.3, pp.796-801, 2008.

[204] Aziza Kamal Genena, Haiko Hense, Artur Smânia Junior, Simone Machado de Souza, "Rosemary (Rosmarinus officinalis) - A Study of the Composition, Antioxidant and Antimicrobial Activities of Extracts Obtained with Supercritical Carbon Dioxide", Ciencia E Tecnologia De Alimentos, vol.28, no.2, pp.463-469, 2008.

[205] Ivana Karabegov, Milena Nikolova, Dragan Velickovic, Sasa Stojicic, Vlada Veljkovic, Midorag Luzic, "Comparison of Antioxidant and Antimicrobial Activities of Methanolic Extracts of the Artemisia sp Recovered by Different Extraction Techniques", Chinese Journal of Chemical Engineering, vol.19, no.3, pp.504-511, 2011.

[206] Keyvan Dastmalchi, H. T. Damien Dorman, Paivi P. Oinonen, Yusrida Darwis, Into Laakso, Raimo Hiltunen, "Chemical Composition and in Vitro Antioxidative Activity of a Lemon Balm (Melissa officinalis L.) Extract", Lwt-Food Science and Technology, vol.41, no.3, pp.391-400, 2008.

[207] Yingming Pan, Chunhuan He, Hengshan Wang, Xiaowen Ji, Kai Wang, Peizhen Liu, "Antioxidant Activity of Microwave-Assisted Extract of Buddleia officinalis and its Major Active Component", Food Chemistry, vol.121, no.2, pp.497-502, 2010.