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# Food Phenolic Compounds: Main Classes, Sources and Their Antioxidant Power

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Additional information is available at the end of the chapter

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## 1. Introduction

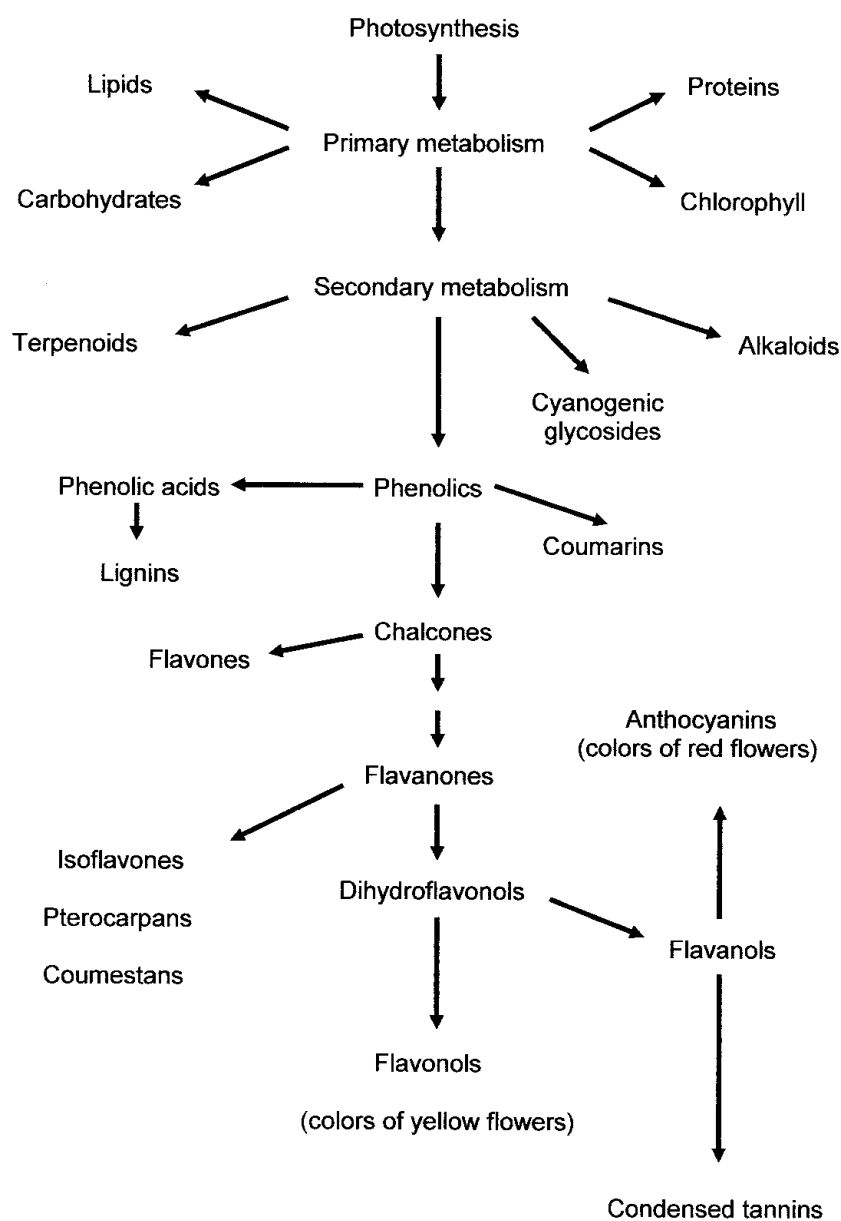
The natural phenolic compounds have received increasing interest in the last years, since a great amount of them can be found in plants and consumption of vegetables and beverages with a high level of such compounds may reduce the risk of development of several diseases due to their antioxidant power, among other factors.

It is known that the metabolism of plants is divided in primary and secondary. The substances that are common to living things and essential to cells maintenance (lipids, proteins, carbohydrates, and nucleic acids) are originated from the primary metabolism. On the other hand, substances originated from several biosynthetic pathways and that are restricted to determined groups of organisms are results of the secondary metabolism [1]. Phenolic compounds are constituted in one of the biggest and widely distributed groups of secondary metabolites in plants [2].

Figure 1 shows the inter-relationships between the primary and secondary metabolism in plants.

Biogenetically, phenolic compounds proceed of two metabolic pathways: the shikimic acid pathway where, mainly, phenylpropanoids are formed and the acetic acid pathway, in which the main products are the simple phenol [3]. Most plants phenolic compounds are synthesized through the phenylpropanoid pathway [4]. The combination of both pathways leads to the formation of flavonoids, the most plentiful group of phenolic compounds in nature [3].

Additionally, through the biosynthetic pathways to the flavonoids synthesis, among the not well elucidated condensation and polymerization phases, the condensed tannins or non-hydrolysable tannins are formed. Hydrolysable tannins are derivatives of gallic acid or hexahydroxydiphenic acid [5].



**Figure 1.** Inter-relationships between the primary and secondary metabolism in plants.

Therefore, phenolic compounds have, as a common characteristic, the presence of at least one aromatic ring hydroxyl-substituted [6]. Another characteristic of these substances is that they are presented commonly bound to other molecules, frequently to sugars (glycosyl residue) and proteins. The existence of phenolic compounds in free form also occurs in plant tissues. However, it is less common, possibly because they are toxic when present in the free state and detoxified, at least in part, when bound.

As a result, phenolic compounds play a role of protection against insects and other animals to the plants. The different types of bond between the glycosyl residue and the flavonoids,

such as anthocyanin, also lead to the different derivatives that add colors and color gradation to flowers [7].

This way, phenolic compounds are essential to the physiology and cellular metabolism. They are involved in many functions in plants, such as sensorial properties (color, aroma, taste and astringency), structure, pollination, resistance to pests and predators, germinative processes of seed after harvesting and growth as well as development and reproduction, among others [8].

Phenolic compounds can be classified in different ways because they are constituted in a large number of heterogeneous structures that range from simple molecules to highly polymerized compounds.

According to their carbon chain, phenolic compounds can be divided into 16 major classes [9].

The main classes of phenolic compounds regarding to their carbon chain can be seen in Figure 2.

On the other hand, as to their distribution in nature, phenolic compounds can be divided into three classes: *shortly distributed* (as simple phenols, pyrocatechol, hydroquinone, resorcinol, Aldehydes derived from benzoic acids that are components of essential oils, such as vanillin), *widely distributed* (divided in flavonoids and their derivatives, coumarins and phenolic acids, such as benzoic and cinnamic acid and their derivatives) and *polymers* (tannin and lignin) [10].

Finally, as to the location in the plant (free in the soluble fraction of cell or bound to compounds of cell wall), together with the chemical structure of these substances, phenolic compounds may also be classified as: *soluble* (such as simple phenol, flavonoids and tannins of low and medium molecular weight not bound to membranes compounds) and *insoluble* (essentially constituted by condensed tannins, phenolic acids and other phenolic compounds of low molecular weight bound to cell wall polysaccharides or proteins forming insoluble stable complexes). This classification is useful from the nutritional viewpoint, to the extent that the metabolic fate in the gastrointestinal tract and the physiological effects of each group will depend largely on their solubility characteristics. Insoluble phenolic compounds are not digested and may be partially or fully recovered quantitatively in the feces, while a part of the soluble can cross the intestinal barrier and be found in the blood, unchanged or as metabolites [3].

The antioxidant activity of food phenolic compounds is of nutritional interest, since it has been associated with the potentiation of the promoting effects of human health through the prevention of several diseases [11]. Additionally, in some cases, these compounds may also be used with therapeutic purposes due to their pharmacological properties [12]. Many phenolic compounds with low molecular weight, such as thymol, are used in medicine as anti-septic due to its toxicity [7].

However, the antioxidant activity of phenolic compounds depends largely on the chemical structure of these substances [2]. Among the phenolic compounds with known antioxidant activity, flavonoids, tannins chalcones and coumarins as well as phenolic acids are highlighted.






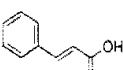
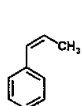




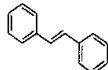
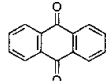
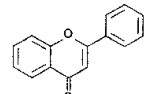
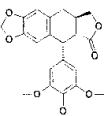
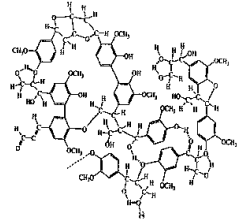
Class	Basic skeleton	Basic structure
Simple phenols	C <sub>6</sub>	
Benzoquinones	C <sub>6</sub>	
Phenolic acids	C <sub>6</sub> -C <sub>1</sub>	
Acetophenones	C <sub>6</sub> -C <sub>2</sub>	
Phenylacetic acids	C <sub>6</sub> -C <sub>2</sub>	
Hydroxycinnamic acids	C <sub>6</sub> -C <sub>3</sub>	
Phenylpropenes	C <sub>6</sub> -C <sub>3</sub>	
Coumarins, isocoumarins	C <sub>6</sub> -C <sub>3</sub>	
Chromones	C <sub>6</sub> -C <sub>3</sub>	
Naphthoquinones	C <sub>6</sub> -C <sub>4</sub>	
Xanthenes	C <sub>6</sub> -C <sub>1</sub> -C <sub>6</sub>	
Stilbenes	C <sub>6</sub> -C <sub>2</sub> -C <sub>6</sub>	
Anthraquinones	C <sub>6</sub> -C <sub>2</sub> -C <sub>6</sub>	
Flavonoids	C <sub>6</sub> -C <sub>3</sub> -C <sub>6</sub>	
Lignans and neolignans	(C <sub>6</sub> -C <sub>3</sub> ) <sub>2</sub>	
Lignins	(C <sub>6</sub> -C <sub>3</sub> ) <sub>n</sub>	

Figure 2. Main classes of phenolic compounds regarding to their carbon chain.

## 2. Main Classes

### 2.1. Flavonoids

According to the degree of hydroxylation and the presence of a C<sub>2</sub>-C<sub>3</sub> double bond in the heterocycling pyrone ring, flavonoids can be divided into 13 classes [3], the most important being represented by the flavonols, flavanols, flavones, isoflavones, anthocyanidins or anthocyanins and flavanones [2]. Within these classes there are many structural varia-





































- [8] Tomás-Barberán, F. A., & Espín, J. C. (2001). Phenolic compounds and related enzymes as determinants of quality in fruits and vegetables. *Journal of the Science of Food and Agriculture*, 81(9), 853-876.
- [9] Harborne, J. B. (1989). Methods in plant biochemistry. In: Dey PM, Harborne JB. (ed.) Plant phenolics. London: Academic Press, 1.
- [10] Bravo, L. (1998). Polyphenols: chemistry, dietary sources, metabolism and nutritional significance. *Nutrition Reviews*, 56(11), 317-333.
- [11] Lampe, J. W. (1999). Health effects of vegetables and fruit: assessing mechanisms of action in human experimental studies. *The American Journal of Clinical Nutrition*, 70, 475S-490S.
- [12] Percival, M. (1998). Antioxidants. *Clinical Nutrition Insights*, 10, 1-4.
- [13] Duthie, G. G, Gardner, P. T, & Kyle, J. A. M. (2003). Plant polyphenols: are they the new magic bullet? *Proceedings of the Nutrition Society*, 62(3), 599-603.
- [14] Hertog, M. G. L., Hollman, P. C. H., & Venema, D. P. (1992). Optimization of a quantitative HPLC determination of potentially anticarcinogenic flavonoids in vegetables and fruits. *Journal of Agricultural and Food Chemistry*, 40(9), 1591-1598.
- [15] Jovanovic, S. V., Steenken, S., Tomic, M., Marjanovic, B., & Simic, M. G. (1994). Flavonoids as antioxidants. *Journal of the American Chemical Society*, 116(11), 4846-4851.
- [16] Sánchez-Moreno, C. (2002 ). Compuestos polifenólicos: efectos fisiológicos: actividad antioxidante. *Alimentaria*, 329, 29-40.
- [17] Rice-Evans, C., Miller, N. J., & Paganga, G. (1996). Structure-antioxidant activity relationships of flavonoids and phenolic acids. *Free Radical Biology and Medicine*, 20(7), 933-956.
- [18] Chung, K. T., Wong, T. Y., Wei, C. I., Huang, Y. W., & Lin, Y. (1998). Tannins and human health: a review. *Critical Reviews in Food Science and Nutrition*, 38(6), 421-464.
- [19] Ragan, M. A., & Glombitza, K. (1986). Phlorotannin: Brown algal polyphenols. *Progress in Physiological Research*, 4, 177-241.
- [20] Okuda, T., Yoshida, T., & Hatano, T. (1995). Hidrolyzable tannins and related polyphenols. *Fortschritte der Chemie organischer Naturstoffe*, 66, 1-117.
- [21] Karakaya, S. (2004). Bioavailability of phenolic compounds. *Critical Reviews in Food Science and Nutrition*, 44(6), 453-464.
- [22] Matern, V., Lüer, P., & Kreuzsch, D. (1999). Biosynthesis of coumarins. In: Barton D, Nakanishi K, Meth-Cohn O, Sankawa V. (ed.) Comprehensive natural products chemistry: polyketides and other secondary metabolites including fatty acids and their derivatives. Amsterdam: Elsevier Science, 623-637.
- [23] Pratt, D. E., & Hudson, B. J. F. (1990). Natural antioxidant not exploited commercially. In: Hudson B. J. F. (ed.) Food antioxidants. London: Elsevier Applied sciences, 171-180.

- [24] Yang, C. S., Landau, J. M., Huang, M. T., & Newmark, H. L. (2001). Inhibition of carcinogenesis by dietary polyphenolic compounds. *Annual Review of Nutrition*, 21, 381-406.
- [25] Martínez-Valverde, I., Periago, M. J., & Ros, G. (2000). Significado nutricional de los compuestos fenólicos de la dieta. *Archivos Latinoamericanos de Nutrición*, 50(1), 5-18.
- [26] Martin, K. R., & Appel, C. L. (2010). Polyphenols as dietary supplements: A double-edged sword. *Nutritional and Dietary Supplements*, 2, 1-12.
- [27] Oboh, G. (2006). Antioxidant properties of some commonly consumed and underutilized tropical legumes. *European Food Research and Technology*, 224(1), 61-65.
- [28] Malencić, D., Popović, M., & Miladinović, J. (2007). Phenolic content and antioxidant properties of soybean (*Glycine max* (L.) Merr.) seeds. *Molecules*, 12(3), 576-581.
- [29] Kováčová, M., & Malinová, E. (2007). Ferulic and coumaric acids, total phenolic compounds and their correlation in selected oat genotypes. *Czech Journal of Food Sciences*, 25(6), 325-332.
- [30] Lv, J., Yu, L., Lu, Y., Nui, Y., Liu, L., Costa, J., & Yu, L. (2012). Phytochemical compositions, and antioxidant properties, and antiproliferative activities of wheat flour. *Food Chemistry*, doi: 10.1016/j.foodchem.2012.04.141.
- [31] Kaur, C., & Kapoor, H. C. (2002). Anti-oxidant activity and total phenolic content of some Asian vegetables. *International Journal of Food Science and Technology*, 37(2), 153-161.
- [32] Isabelle, M., Lee, B. L., Lim, M. T., Koh, W. P., Huang, D., & Ong, C. N. (2010). Antioxidant activity and profiles of common vegetables in Singapore. *Food Chemistry*, 120(4), 993-1003.
- [33] Ayaz, F. A., Hayirhoglu-Ayaz, S., Alpay-Karaoglu, S., Grúz, J., Valentová, K., Ulrichová, J., & Strnad, M. (2008). Phenolic acid contents of kale (*Brassica oleraceae* L. var. *acephala* DC.) extracts and their antioxidant and antibacterial activities. *Food Chemistry*, 107(1), 19-25.
- [34] Javanmardi, J., Stushnoff, C., Locke, E., & Vivanco, J. M. (2003). Antioxidant activity and total phenolic content of Iranian *Ocimum* accessions. *Food Chemistry*, 83(4), 547-550.
- [35] Lu, X., Wang, J., Al-Qadiri, H. M., Ross, C. F., Powers, J. R., Tang, J., & Rasco, B.A. (2011). Determination of total phenolic content and antioxidant capacity of onion (*Allium cepa*) and shallot (*Allium oschaninii*) using infrared spectroscopy. *Food Chemistry*, 129(2), 637-644.
- [36] Agbor, G. A., Vinson, J. A., Oben, J. E., & Ngogang, J. Y. (2006). Comparative analysis of the in vitro antioxidant activity of white and black pepper. *Nutrition Research*, 26(12), 659-663.

- [37] Agbor, G. A., Oben, J. E., Ngogang, J. Y., Xinxing, C., & Vinson, J. A. (2005). Antioxidant capacity of some herbs/spices from Cameroon: A comparative study of two methods. *Journal of Agricultural and Food Chemistry*, 53(17), 6819-6824.
- [38] Marinova, D., Ribarova, F., & Atanassova, M. (2005). Total phenolics and total flavonoids in Bulgarian fruits and vegetables. *Journal of the University of Chemical Technology and Metallurgy*, 40(3), 255-260.
- [39] Dragović-Uzelac, V., Savić, Z., Brala, A., Levaj, B., Kovacević, D. B., & Biško, A. (2010). Evaluation of phenolic content and antioxidant capacity of blueberry cultivars (*Vaccinium corymbosum* L.) grown in the Northwest Croatia. *Food Technology and Biotechnology*, 48(2), 214-221.
- [40] Melicháková, S., Timoracká, M., Bystrická, J., Vollmannová, A., & Céry, J. (2010). Relation of total antiradical activity and total polyphenol content of sweet cherries (*Prunus avium* L.) and tart cherries (*Prunus cerasus* L.). *Acta Agriculturae Slovenica*, 95(1), 21-28.
- [41] Guimarães, R., Barros, L., Barreira, J. C. M., Sousa, M. J., Carvalho, A. M., & Ferreira, I. C. F. R. (2010). Targeting excessive free radicals with peels and juices of citrus fruits: grapefruit, lemon, lime and Orange. *Food and Chemical Toxicology*, 48(1), 99-106.
- [42] Thaipong, K., Boonprakob, U., Crosby, K., Zevallos, L. C., & Byrne, D. H. (2006). Comparison of ABTS, DPPH, FRAP, and ORAC assays for estimating antioxidant activity from guava fruit extracts. *Journal of Food Composition and Analysis*, 19(6), 669-675.
- [43] Gorinstein, S., Haruenkit, R., Poovarodom, S., Park, Y. S., Vearasilp, S., Suhaj, M., Ham, K. S., Heo, B. G., Cho, J. Y., & Jang, H. G. (2009). The comparative characteristics of snake and kiwi fruits. *Food and Chemical Toxicology*, 47(8), 184-189.
- [44] Fu, L., Xu, B. T., Xu, X. R., Gan, R. Y., Zhang, Y., Xia, E. Q., & Li, H. B. (2011). Antioxidant capacities and total phenolic contents of 62 fruits. *Food Chemistry*, 129(2), 345-350.
- [45] Gil, M. I., Tomás-Barberán, F. A., Hess-Pierce, B., & Kader, A. A. (2002). Antioxidant capacities, phenolic compounds, carotenoids, and vitamin C contents of nectarine, peach, and plum cultivars from California. *Journal of Agricultural and Food Chemistry*, 50(17), 4976-4982.
- [46] Gansch, H., Weber, C. A., & Lee, C. Y. (2009). Antioxidant capacity and phenolic phytochemicals in black raspberries. *New York State Horticultural Society*, 17(1), 20-23.
- [47] Pineli, L. L. O., Moretti, C. L., dos Santos, S. M., Campos, A. B., Brasileiro, A., Córdova, A. C., & Chiarello, M. D. (2011). Antioxidants and other chemical and physical characteristics of two strawberry cultivars at different ripeness stages. *Journal of Food Composition and Analysis*, 24(1), 11-16.



- [48] Jolić, S. M., Redovniković, I. R., Marković, K., Šipušić, Đ. I., & Delonga, K. (2011). Changes of phenolic compounds and antioxidant capacity in cocoa beans processing. *International Journal of Food Science and Technology*, 46(9), 1793-1800.
- [49] Baroni, M. V., Naranjo, R. D. D. P., García-Ferreira, C., Otaiza, S., & Wunderlin, D. A. (2012). How good antioxidant is the red wine ? Comparison of some in vitro and in vivo methods to assess the antioxidant capacity of Argentinean red wines. *LWT-Food Science and Technology*, 47(1), 1-7.
- [50] Lee, KW, Lee, HJ, & Lee, CY. (2002). Antioxidant activity of black tea vs. green tea. *Journal of Nutrition*, 132(4), 785.
- [51] Natella, F., Nardini, M., Belevi, F., & Scaccini, C. (2007). Coffee drinking induces incorporation of phenolic acids into LDL and increases the resistance of LDL to ex vivo oxidation in humans. *The American Journal of Clinical Nutrition*, 86(3), 604-609.
- [52] Pellegrini, N., Serafini, M., Colombi, B., Del Rio, D., Salvatore, S., Bianchi, M., & Brighenti, F. (2003). Total antioxidant capacity of plant foods, beverages and oils consumed in Italy assessed by three different in vitro assays. *Journal of Nutrition*, 133(9), 2812-2819.
- [53] Thiagarajan, G., Chandani, S., Sundari, C. S., Rao, S. H., Kulkarni, A. V., & Balasubramanian, P. (2001). Antioxidant properties of green and black tea, and their potential ability to retard the progression of eye lens cataract. *Experimental Eye Research*, 73(3), 393-401.
- [54] King, A., & Young, G. (1999). Characteristics and occurrence of phenolic phytochemicals. *Journal of the American Dietetic Association*, 99(2), 213-218.
- [55] Handelman, G. J., Cao, G., Walter, M. F., Nightingale, Z. D., Paul, G. L., Prior, R. L., & Blumberg, J. B. (1999). Antioxidant capacity of oat (*Avena sativa* L.) extracts. 1. Inhibition of low-density lipoprotein oxidation and oxygen radical absorbance capacity. *Journal of Agricultural and Food Chemistry*, 47(12), 4888-4893.
- [56] Jaiswal, A. K., Abu-Ghannam, N., & Gupta, S. (2012). A comparative study on the polyphenolic content, antibacterial activity and antioxidant capacity of different solvent extracts of Brassica oleracea vegetables. *International Journal of Food Science and Technology*, 47(2), 223-231.
- [57] Vieira, F. G. K., Borges, G. S. C., Copetti, C., Pietro, P. F., Nunes, E. C., & Fett, R. (2011). Phenolic compounds and antioxidant activity of the apple flesh and peel of eleven cultivars grown in Brazil. *Scientia Horticulturae*, 128(3), 261-266.
- [58] Mitić, M. N., Obradović, M. V., Kostić, D. A., Micić, R. J., & Pecev, E. T. (2012). Polyphenol content and antioxidant activity of sour cherries from Serbia. *Chemical Industry and Chemical Engineering*, 18(1), 53-62.
- [59] Çekiç, Ç., & Özgen, M. (2010). Comparison of antioxidant capacity and phytochemical properties of wild and cultivated red raspberries (*Rubus idaeus* L.). *Journal of Food Composition and Analysis*, 23(6), 540-544.

- [60] Rupasinghe, H. P. V., Jayasankar, S., & Lay, W. (2006). Variation in total phenolics and antioxidant capacity among European plum genotypes. *Scientia Horticulturae*, 108(3), 243-246.
- [61] Khallouki, F., Haubner, R., Erben, G., Ulrich, C. M., & Owen, R. W. (2012). Phytochemical composition and antioxidant capacity of various botanical parts of the fruits of *Prunus × domestica* L. from the Lorraine region of Europe. *Food Chemistry*, 133(3), 697-706.
- [62] Sánchez, A. C. G., Gil-Izquierdo, A., & Gil, M. I. (2003). Comparative study of six pear cultivars in terms of their phenolic and vitamin C contents and antioxidant capacity. *Journal of the Science of Food and Agriculture*, 83(10), 995-1003.
- [63] Fischer, U. A., Carle, R., & Kammerer, D. R. (2011). Identification and quantification of phenolic compounds from pomegranate (*Punica granatum* L.) peel, mesocarp, aril and differently produced juices by HPLC-DAD-ESI/MS. *Food Chemistry*, 122(2), 807-821.
- [64] Jayaprakasha, G. K., Girenavar, B., & Patil, B. S. (2008 ). Radical scavenging activities of Rio Red grapefruits and Sour orange fruit extracts in different in vitro model systems. *Bioresource Technology*, 99(10), 4484-4494.
- [65] Jayaprakasha, G. K., Girenavar, B., & Patil, B. S. (2008 ). Antioxidant capacity of pummelo and navel oranges: Extraction efficiency of solvents in sequence. *Lebenson Wiss Technology*, 41(3), 376-384.
- [66] Rufino, M. S. M., Alves, R. E., Brito, E. S., & Pérez-Jiménez, J. (2010). Bioactive compounds and antioxidant capacities of 18 non-traditional tropical fruits from Brazil. *Food Chemistry*, 121(4), 996-1002.
- [67] Contreras-Calderón, J, Calderón-Jaimes, L, Guerra-Hernández, E, & García-Villanova, B. (2011). Antioxidant capacity, phenolic content and vitamin C in pulp, peel and seed from 24 exotic fruits from Colombia. *Food Research International*, 44(7), 2047-2053.
- [68] Adamson, G. E., Lazarus, A. S., Mitchell, A. E., Prior, R. L., Cao, G., Jacobs, P. H., Kremers, B. G., Hammerstone, J. F., Rucker, R. B., Ritter, K. A., & Schmitz, H. H. (1999). HPLC method for the quantification of procyanidins in cocoa and chocolate samples and correlation to total antioxidant capacity. *Journal of Agricultural and Food Chemistry*, 47(10), 4184-4188.
- [69] Rivero-Pérez, M. D., Muñoz, P., & González-Sanjosé, M. L. (2007). Antioxidant profile of red wines evaluated by total antioxidant capacity, scavenger activity, and biomarkers of oxidative stress methodologies. *Journal of Agricultural and Food Chemistry*, 55(14), 6476-5483.
- [70] Moure, A., Cruz, J. M., Franco, D., Domínguez, J. M., Sineiro, J., Domínguez, H., Núñez, M. J., & Parajó, J. C. (2001). Natural antioxidants from residual sources. *Food Chemistry*, 72(2), 145-171.

- [71] Lee, K. W., Kim, Y. J., Lee, H. J., & Lee, C. Y. (2003). Cocoa has more phenolic phytochemicals and a higher antioxidant capacity than teas and red wine. *Journal of Agricultural and Food Chemistry*, 51(25), 7292-7295.
- [72] Bravo, J., Monente, C., Juárez, I., Peña, M. P., & Cid, C. (2011). Influence of extraction process on antioxidant capacity of spent coffee. *Food Research International*, doi: 10.1016/j.foodres.2011.04.026.
- [73] Duthie, G. G., Duthie, S. J., & Kyle, J. A. M. (2000). Plant polyphenols in cancer and heart disease: implications as nutritional antioxidants. *Nutrition Research Reviews*, 13(1), 79-106.
- [74] Giada, M. L. R., & Mancini-Filho, J. (2009). Antioxidant capacity of the striped sunflower (*Helianthus annuus* L.) seed extracts evaluated by three in vitro methods. *International Journal of Food Sciences and Nutrition*, 60(5), 395-401.

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