



## Bioavailability of Functional Food Constituents: A Controversial Research Field

Monica Rosa Loizzo\*

Department of Pharmacy, University of Calabria, I-87036 Rende, Italy

### Editorial

Recently consumer demands in the field of food has significantly changed. Consumers, in fact, are aware of that food is related to their health [1]. Even the concept of food has undergone in recent years a profound transformation since it is not only to provide necessary nutrients for humans but also to prevent diseases and improve physical and mental consumer health [2]. In this regard, functional foods play an outstanding role. There is no official definition of Functional Foods common to all States since in several Countries there is no legislation. Actually “functional foods” can be definite as “foods that may provide health benefits beyond basic nutrition” or “food similar in appearance to conventional food that is intended to be consumed as part of a normal diet, but has been modified to sub serve physiological roles beyond the provision of simple nutrient requirements” [3]. In the past decades, the functional foods market growing rapidly and dynamically. Data from Euromonitor 2010 revealed that the value of their global market is 168 billion in US\$ with worldwide annual growth rate of 7.2% in the 10 years to 2017 [4]. The first Functional Foods to be developed were fortified food, in which food are enriched in vitamins such as C and E, folic acid, calcium, iron, and zinc. Afterward, omega-3 fatty acid, phytosterol, soluble fiber and micronutrients such as polyphenols, carotenoids etc. were added [5].

One of the most critical aspects of the activity of functional foods regards the possibility that their constituent remain “active” and “bioavailable” even after processing. When consumers consume a functional food or functional drink, the bioactive constituents contained are released from the dietary matrix, metabolized under the action of digestive enzymes, absorbed into the bloodstream, transported to their respective target tissues or excreted via urine or faeces. However, not all constituents can be used to the same extent since they differ in their bioavailability. Bioavailability is defined as the amount of an ingested nutrient that is available for absorption in the gut after digestion. Therefore, the bioavailability of a nutrient is directed by internal and external and factors. Internal factors are age, gender, nutrient status and particular health-condition (e.g. pregnancy, diseases) whereas the release of the functional constituents from food matrix and its chemical form that allow to permit to enter into the gut cells or pass between them were considered as external factors [6]. The bioavailability of macronutrients such as carbohydrates, proteins, fats is usually more than 90% of the amount ingested while minerals, vitamins and bioactive phytochemicals such as carotenoids, flavonoids etc. can vary widely in the extent they are absorbed and consumed.

Among mineral a classic example is iron. Dietary iron has two main forms: heme and non-heme. Nuts, beans, vegetables, and fortified grain products contain non-heme iron only, whereas meat, seafood, and poultry contain both form. Generally, heme iron has higher bioavailability than non-heme iron with a bioavailability value approximately of 14-18%. When heme-iron is released from the food matrix, the heme group protect the central iron atom and allow permitting it absorption through a specific transport system on the surface of the gut cells (Hurrell “et al.”, 2010).

Folate or vitamin B is recognized as beneficial health-wise in anemia, cardiovascular diseases, in the prevention of neural tube defects etc. Several national health authorities have introduced mandatory food fortification with synthetic folic acid characterized by a superior bioavailability and bioefficacy. Recently, Ohrvik & Witthoft [7] demonstrated that limited folate bioavailability (20-70%) for vegetables, fruits, breakfast cereal products. For the above-mentioned reasons they recommend to use synthetic folic acid. This does not mean though that one should only consume foods fortified with folic acid, but rather that natural dietary sources such as green leafy vegetables can be complemented with foods fortified with this vitamin to ensure that individual requirements are met. The possibility that the bioavailability of vitamin C from natural sources might be different from that of synthetic was investigated in two human studies, and no clinically

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#### \*Correspondence:

Monica Rosa Loizzo, Department of Pharmacy, Health and Nutritional Sciences, University of Calabria, I-87036 Rende (CS), Italy, Tel: +390984493071; Fax: +390984493107; E-mail: monica\_rosa.loizzo@unical.it

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significant differences were observed. In particular, Gregory [8] demonstrated that vitamin C derived from orange products or cooked broccoli is equally bioavailable. A controversial interference with vitamin C bioavailability was observed when in food matrix both vitamin C and flavonoids are contained. Uchida “et al.” [9]. Showed a significant reduction in urinary excretion of vitamin C in the presence of flavonoids whereas Jones “et al.” [10]. Observed an increased level of vitamin after consumption of flavonoids rich juice such as kiwifruit and blackcurrant. Among phytochemicals with functional properties, carotenoids and flavonoids are predominant. Carotenoids are enclosed in plant cell walls and cell organelles. Their bioavailability may be also influenced by cooking, fat content and by the presence of fibers [11]. Carotenoid release from the food matrix can be enhanced by cooking or freezing however, the literature on the effect of cooking and processing is controversial [11,12]. A low bioavailability was observed also for flavonoids. For example, urinary excretion of anthocyanins was 43%. Moreover their content in food matrix can be influenced, also by temperature, pH, light, oxygen, presence of enzymes, proteins, metallic ions and other flavonoids. Flavonoids with complex structures and larger molecular weights can reach out to a bioavailability may be even lower [13]. Rodriguez-Mateos “et al.” [14]. Investigated the effect of processing in blueberry polyphenols. Although processing did not significantly change the total phenols content, the processed products contained significantly less anthocyanins, more chlorogenic acid, and significantly more flavanol. A flow-mediated dilation was observed after consumption of the baked products to a similar degree as the unprocessed blueberries, despite significant differences in the levels of individual plasma metabolites.

Bioactive food compounds, whether derived from various sources, need to be bioavailable in order to exert any health effects. Several factors affect bioavailability, such as molecular structures, food matrix release, transporters, and metabolizing enzymes. Bioefficacy may be improved through enhanced bioavailability. Therefore, several technologies have been developed to improve the bioavailability, including structural modifications, nanotechnology and colloidal systems. Due to the complex nature of food bioactive constituents and the different mechanisms of their absorption, distribution and excretion unravelling the bioavailability of food bioactive constituents is challenging. Even though there are several research investigations reporting on bioavailability and bioefficacy of these bioactive food constituents, the literature appear sometimes controversial. For the above-mentioned reasons further studies are necessary to understanding their interactions, metabolism and mechanism of action.

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