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Food matrix: A new tool to enhance nutritional quality of food

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Abstract
Food matrix can be described as a complex assembly of various physical and chemical interactions that take place between the compounds present in the food. The physiological response and the health benefits of a particular compound are resultant on these interactions. The sensorial attributes of a particular brand and the level of satiety also depend upon on the food matrix. Enhancement of functional and sensorial attributes of food can be achieved by modifying the food matrix. Food matrices are designed to improve various attributes of food. Excipient foods are designed to improve the bioavailiabity of bioactive compounds in food.

Keywords: Food matrix, Perception, Satiety, bioaccessibility, nutrition

Introduction
Nutrients and bioactive components are present in various foods that are normally consumed but the physiological response and the health benefits of different foods containing the same nutrients and bioactive components are different. The reason behind this discrepancy is that the amount of nutrients actually digested and the amount actually absorbed are different for different foods. The compounds present in the food interact with the different matrix in different ways. The food matrix is described as an assembly where complex physical and chemical interaction of nutrients and non-nutrients take place. The release, stability, accessibility, mass transfer and digestibility of many food compounds are influenced by this complex physical and chemical interaction (Crowe and Francis, 2013) [8]. It has also been observed that compounds in whole foods behave in a different manner than when it is in isolated form. This is also due to the differences in the food matrix in which the bioactive compounds are present. Food matrix can be modified using various processing techniques and fermentation. Special food matrix can also be designed for increasing the bioavailability and bioaccessibility of the nutrients. This paper reviews about the basic concept of food matrix and its implications along with that the impact of food matrix on nutrition and sensorial aspects of foods is also depicted. The concept of "Excipient foods" is included.

Food matrix
The food matrix is described as an assembly where complex physical and chemical interaction of nutrients and non-nutrients take place. The release, stability, accessibility, mass transfer and digestibility of many food compounds are influenced by this complex physical and chemical interaction (Crowe and Francis, 2013) [8]. The digestion and absorption of food compounds in the gastrointestinal tract is directly affected by the food matrix. Food matrix also has important role in the microbial fermentation of some compounds which occurs in the colon and also in the absorption of resultant metabolites. Food compounds after getting absorbed in gastrointestinal tract enters to the systemic circulation. But before the release to the systemic circulation, in the intestinal epithelium and the liver, these compounds undergo some. (Motilva *et al.,* 2015) [22].

Food matrix is directly related to the amount of nutrients released during digestion and the amount actually absorbed in the intestine. The specific physiological responses of the food components in the body depend upon the biotransformation of the food components. Food matrix plays a relevant role in these biochemical transformations. To assess the potential nutritional benefits of nutrients and bioactive compounds and to validate their physiological benefits bioavailability (amount of nutrients absorbed), rather than the amount of nutrient intake, has become the criterion (Holst and Williamson 2008; Rein *et al.,* 2013; Pressman *et al.,* 2017) [14, 26]. Food matrix modifies the bioactive component in the food. So, the physiological effect a bioactive component in a food can be changed by modifying the food matrix. It also the implies that food with similar chemical composition can have

different physiological response when consumed. In case of carotenoids, when it is consumed as oil dissolved supplements bioavaliabilty was five times higher than when consumed from raw carrots (Casten miller and West, 1998) [4]. (Dufour *et al.*, 2018) has found that polyphenols, when consumed raw as fruits has poor bioaccessibility (amount of nutrients released during digestion).It may be deduced that the food matrix is component-specific, i.e., the interaction or response of different components in the same food may differ with different matrices. When milk or cream is heated whey proteins in the milk plasma (whey) undergoes denaturation, while melting of milk fat occur inside the fat globule (Kulozik, 2008) [16].

Food matrix can be modified to improve various aspects of food and aspects related to ingestion. Processing (including cooking) is a controlled and calculated effort to preserve, transform, create and destroy edible structures (Aguilera and Stanley, 1999; Aguilera, 2016) [2, 1]. During food processing some major changes takes place, in their chemical condition (solubilization and thermal reactions), physical state (state and phase transitions) and dispersion or aggregation of components (gelation, emulsification) etc (Bhandari and Roos, 2012) [3]. (Parada and Aguilera, 2007; Sensoy, 2014) [24, 29] has studied the relationship between processing and the modification of food matrix, and its effectsondigestion, quality and physiological response. Cooking of various food substances like tubers, legumes and cereals makes the texture softer and thereby increases the digestibility, since the solubilization of the intercellular cement holding the matrix takes place, along with starch gelatinization (Singh *et al.*, 2010; Aguilera and Stanley, 1999) [30, 2]. The bioavailability and antioxidant capacity of functional compounds present in fruit can be improved by the homogenisation of the flesh of the fruit (Quiros-Sauceda *et al.*, 2017) [23]. Fermentation causes favourable changes in food matrices by creating new flavours, metabolites and textures. During sprouting partial hydrolysis of proteins and starch will occur which in turn increases its digestibility (Lorenz and D' Appolonia, 1980) [8]. Due to the action of enzymes, on the cells, produced by the microorganisms, the matrix will become more permeable and the bio accessibility of the nutrients will increase consequently.

Perception, Satiety and Food matrix

After ingestion of food the digestion process starts from the mouth. The taste, body and texture of the food is perceived in mouth. During chewing or mastication reduction of size and disintegration of food matrix occurs. Components released from the disintegrated food matrix interact with the salivary enzymes and produce taste perception. Astringency of various food products like tea, coffee beer and chocolate are perceived when the polyphenols from these products are reacted with the proline-rich salivary enzymes (Gallo *et al.*, 2013) [12]. To perceive the flavour of the food the flavour compounds should be released from the food matrix during mastication (Salles *et al.*, 2010; Guichard and Salles, 2016) [13, 27]. The level of perception changes as the composition changes. Lipids in foods has profound influence on aroma compounds as it separates the compound among aqueous and oil phase and in more polysaccharide containing foods the flavour perception will be less as the food matrix is viscous so the compounds are not easily released (Voilley and Souchon, 2006) [31]. As the strength of the food matrix increases consequently chewing time will also increase and as a result the flavour will linger for a prolonged duration (Wilson and Brown, 1997) [33]. So, while replacing some specific compound with other substances the food matrix has also to be modified to have same flavour perception and we can also modify or mask particular taste by making changes in the matrix. Pungent flavour caused bycapsaicinoidcompounds was more in salsas containing extra starch and oil than in normal ones (Schneider *et al.*, 2014) [28].

Different kind of foods have varied level of satiating properties. Foods containing more fibre and protein has more satiating property also solid foods causes more satiety than liquid foods even if both the foods has same calorific value (Chambers *et al.*, 2015) [5]. By modifying the matrix of the foods, the satiety level of the food can be altered. This has profound effect on making special diet for weight management. Foods containing more gums and gelling fiber produces a high viscosity matrix and these will cause a delayed satiation response since the action of enzymes on food is retarded and also food stay in intestine for prolonged duration (Fiszman and Varela, 2013) [11].

Impact of the food matrix on nutrition

Nutrients in the whole foods have different physiological response compared to when in it is consumed as such. Even though the chemical composition of the foods may be same but it has been found that there are profound differences in biological activity, mode of nutrient delivery and in the health benefits. These differences are due to the complexity of interactions between nutrients, the food matrix (Lecerf and Legrand 2015; Wahlqvist 2016) [17, 32]. Tolower the plasma concentration of LDL cholesterol phytosterol/ phytostanols fortification/enrichment of several foods had been done. It has found that foods in which Phytosterol/ Phytostanol was soluble and contained poly- and monounsaturated fatty acids, LDL lowering effects was very much pronounced (Cusack *et al.*, 2013) [9].

To enhance the bioaccessibility and bioavailability of various bioactive components special food matrices are designed. Food matrices designed to achieve this purpose are of two major classes: functional foods and excipient foods (Mc Clements and Xiao, 2014) [19]. Functional foods: In these foods, the bioactive component is trapped within a natural or processed food matrix. In case of processed foods, if the bioactive component is soluble then the component is added as such, otherwise the component is encapsulated using a suitable system based on the mode of nutrient delivery (Mc Clements, 2015) [20].

Excipient foods: In case of Excipient foods, the natural or processed food containing bioactive component is co-ingested with another food ('excipient food'). The composition and/or structure of the excipient food are designed in such a way so that it will increase the bioavailability of bioactive component. It has been found from the *in vitro* studies of carrots and tomatoes that when digestible lipids are added, thebioaccessibility of carotenoid compounds increased because mixed micelles which was soluble in intestinal fluids was formed (Moelants *et al.*, 2012; Colle *et al.*, 2012; Colle *et al.*, 2013) [21, 7, 8]. It is possible to enhance the bioavailability of ceratin bioactive components by the addition of surface-active compounds like sucrose monoesters (Yamamoto, *et al.*, 2014) [34] and rhamnolipids (Jiang *et al.*, 2013) [15].

Conclusion

It has been found that bioactive compounds act in a different way in whole foods compared to its isolated. This process can be explained by the concept of food matrix. Various aspects

regarding the food are directly related to the food matrix. From flavour perception to the physiological response and the health benefits of foods are result of the subsequent food matrix. So, to improve the sensorial or biological functionality, it can be achieved by modifying the food matrix using various techniques. By understanding the interactions of a bioactive component with various food matrix and its consequent physiological response in body, special food matrix can be designed to improve the bioaccessilbilty and bioavailability of different bioactive compounds

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