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Formulation and Health Benefits of Microencapsulated Green Tea and its Limitations in Food Applications

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Abstract

Tea is a popular beverage made from the fresh leaves of Camellia sinensis. This shrub is grown in Sri Lanka, China, India, Japan and Java. It is a well known alcohol free drink in the world (R.W.N.Tanuja et al., 2016). Tea is presently prepared in over 300 different varieties. On the basis of degree of fermentation, processed tea leaves are of three types: fermented (black tea), semi fermented (oolong tea) and unfermented (green tea) (Hampton et al., 1992). A high degree of enzymatically catalysed aerobic oxidation of the leaf polyphenols is followed by a sequence of chemical condensations in the production of black tea. Green tea is produced by steaming or drying of fresh tea leaves to prevent oxidation of the green tea polyphenols. Oolong tea is partially oxidised (Takeo, 1992). Tea's composition changes according to species, season, leaf age (plucking position), climate as well as horticultural practice. Green tea is rich in polyphenols which includes flavandiols, flavonoids, flavanols and polyphenolic acids.

Introduction

Due to fermentation of tea leaves, there is degradation of chemical compounds including polyphenols and vitamins but in the manufacturing of green tea there is no step of fermentation. Therefore, green tea shows flavors and aroma of the original untreated tea leaves. Green tea is rich in carbohydrates and proteins. Green tea is also rich in polyphenol, amino acids, caffeine, organic acid, lignin and chlorophyll. It also contains flavonols, flavandiols, flavanoids and phenolic acid. Catechins are the another name of the tea flavanols. There are six different types of catechins present in green tea. The major polyphenols present in green tea are . (-)-Epigallocatechin gallate (9-12%), (-)-Epicatechingallate (3-6%), (-)-Epigallocatechin(3-6%), (-)-Epicatechin(1-2%) (Bharadwaz et al., 2012). The polyphenols present in minor amount are (+)-Gallocatechin and (+)-Catechin.

Many scientists analysed that tea polyphenols have antioxidant activity or free radical scavenging activity. Due to this property green tea have various health benefits including anti-carcinogenic, anti-fungal, anti-diabetic, anti-obesity effects, prevention from cardiovascular diseases and inflammatory diseases (rheumatoid arthritis, multiple sclerosis) (R.W.N.Tanuja et al., 2016).

The health benefits of green tea polyphenols improves the nutritional content of food formulations which is highly benefitted to food industry. The addition of natural bioactive components to food is gaining popularity, and green tea polyphenols are one of the most promising bioactive molecules. Unfortunately, it has been discovered that the usage of polyphenols in food is limited due to their sensitivity to a variety of conditions, including temperature, pH, oxygen, light exposure, enzymes, and so forth. (Lu et. al., 2011).
Green tea polyphenols catechins' bitterness and astringency are also key drawbacks for their inclusion into culinary products (Giroux et al., 2013).

In addition, the bioavailability of the active ingredients in the food product represents a challenge as only a small proportion of the molecules remain available after consumption, affected by the detrimental conditions of the gastro-intestinal tract (low gastric pH, low permeability, enzymes, etc.). Therefore, to assure the effectiveness of food products formulated with green tea polyphenols, it is mandatory to apply mechanisms which can protect and preserve the bioactive compounds during process and upon consumption.

Microencapsulation techniques, which have been successfully used in the food industry, represent a solution to the challenge of incorporating green tea polyphenols in food products.
It enables to

(i) Overcome the solubility incompatibilities between ingredients,
(ii) Protect sensitive ingredients such as polyphenols from degradation e.g. by oxidation,
(iii) Increase their bioavailability including the controlled release of encapsulated compounds.

The fortification of food products with microcapsules of green tea polyphenols is a novel approach. Therefore, the aim of the present review is to provide overview of the health benefits of the green tea.

Health benefits

The health benefits associated with tea consumption have been attributed in part to the antioxidant and free radical scavenging activity of the four principal and most abundant tea flavanols: (-)-epigallocatechin (EGC); (-)-epicatechin (EC); (-)-epigallocatechin-3-gallate (EGCG); and (-)-epicatechin-3-gallate (ECG) (Rietveld A & Wiseman S, 2003). It has been shown in different cell lines and animal models that tea flavanols also inhibit cell proliferation, induce cell cycle arrest and apoptosis, stimulate angiogenesis and affect cell signaling pathways (Lambert JD & Yang CS, 2003).

The tea flavanols have antioxidants activity which has been shown clearly in in-vitro experiments. Rietveld and Wiseman (2003) reviewed that after the consumption of tea or tea polyphenols, there is a raise in the plasma antioxidant activity ranged from 2% to 15%. This could be due to the tea flavanol's low bioavailability, as well as the fact that human blood has great physiological antioxidant protection due to its high levels of ascorbic acid, uric acid, glutathione, and other antioxidants. Van Amelsvoort et al., (2001) also discovered a similar trend in plasma uric acid and plasma antioxidant activity after consumption of tea polyphenols. Furthermore, it has been established that the content of various plasma antioxidant molecules is influenced by macronutrient intake (Lotito SB & Frei B, 2004).

Green tea polyphenols became more popular due to its anti-carcinogenic properties. Many epidemiological studies have been carried out to look at the impact of tea consumption on the incidence of cancer in humans. Green tea's anticarcinogenic properties have been linked to the presence of numerous flavonoids from the catechin family, including EGCG (Mukhtar & Ahmad, 1999). Kada et al. (1985) accounted a high bio-antimutagenic effect of green tea polyphenols against spontaneous mutations resulting from altered DNA polymerase III in the strain of *Bacillus subtilis* in their experiment on rats.

Green tea has also been shown to have antibacterial and antiviral properties. Indeed, green tea catechins can act as inhibitors of some enzymes important for microorganisms (Okamoto et al. 2003).

Limitation of green tea polyphenols in food application

Poor bioavailability

A major drawback to green tea polyphenols application in food systems is their poor bioavailability (Bharali et al., 2011). Bioavailability is defined as the fraction of an ingested nutrient or compound that reaches the systemic circulation and the specific sites where it can exert its biological action. Tea polyphenols efficacy is determined by their bioavailability, thus, irrespective of the type of food in which they are incorporated, they required to be bioavailable in order to provide the expected health attributes (Alotaibi et al., 2013). Catechins from green tea are very unstable after passing through salivary, gastric and upper small intestinal phases of the digestion process (Shim et al., 2012). In the present study, the total catechins EGC, and EGCG significantly decreased with digestive recovery of 4.6%, and 6.1%. In addition, the harsh conditions of the gastrointestinal tract (pH, intestinal epithelium, enzymes, gastric juices etc.) are highly detrimental to green tea polyphenols availability (Sun et al., 2012). Finally, the poor bio-availability of EGCG can be attributed to several other factors such as the instability of EGCG in alkaline or neutral conditions, the low cellular uptake due to high aqueous solubility and poor hydrophobicity to cross cell membrane, the metabolic transformations such as methylation, glucuronidation, and sulfation (Chen et al., 2001).

In addition to their low bioavailability, green tea polyphenols are very sensitive to environmental factors, including physical, chemical, and biological conditions which limit their application in the food industry. The food processing conditions (high temperatures, acidic solutions, lipids, pH, etc.) are usually detrimental to tea polyphenols. Polyphenols are highly susceptible to epimerization at higher temperature and alkaline pH which further deteriorates the polyphenols activity. The concentration of total catechins in green tea decreased after a thermal treatment of sterilization (Kim et al., 2007). Furthermore, some studies have reported the occurrence of astringency and bitterness of green tea polyphenols which make it difficult to use in food products.

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