Available online at www.ijpab.com

DOI: http://dx.doi.org/10.18782/2320-7051.3064

ISSN: 2320 – 7051

Int. J. Pure App. Biosci. **5 (6):** 1515-1520 (2017)

Review Article

International Journal of Pure & Applied Bioscience

OPEN ACCESS

Review on Nutraceutical relevance of Green tea polyphenols and Microencapsulation

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Received: 5.02.2017 | Revised: xx.xx.2017 | Accepted: xx.xx.2017

ABSTRACT

Green tea is abundantly enriched with polyphenols which includes: flavanols, catechin (C), epicatechin (EC), gallocatechin (GC), epigallocatechin(EGC), catechin 3-O-gallate (CG), gallocatechin 3-O-gallate(GCG), epicatechin 3-O-gallate (ECG) and epigallo catechin3-O-gallate (EGCG). Polyphenols is of great nutraceutcal importance. Microencapsulation is an enduring technology for protection and controlled release of green tea polyphenols. Spray drying is a well-established method for converting liquid food into a dry powder form and it is one of the most common and economical method employed for microencapsulation. This paper reviews about the health benefits of green tea and its scope of microencapsulation.

Key words: *Green tea,Polyphenols, Microencapsulation, Spray drying.*

INTRODUCTION

The non-fermented Green tea leaves, *Camellia sinensis*, is the second most popular beverage in the world and is becoming increasingly popular day by day, partly because of more documented evidence about its beneficial health properties. Green tea is a rich source of polyphenols (25–40%) and caffeine (3-6%) including flavanols, flavonols, flavanones and phenolic acids[22]. In particular, several recent studies have suggested a role of the tea flavanols in protection against cancer[17], coronary diseases[8] and neurodegeneration[32]. The most abundant green tea polyphenols (GTPs) includes: flavanols,catechin (C), epicatechin (EC), gallocatechin (GC), epigallocatechin(EGC), catechin 3-*O*-gallate (CG), gallocatechin 3-*O*-gallate(GCG), epicatechin 3-*O*-gallate (ECG) and epigallo catechin3-*O*-gallate (EGCG).The current interest in the health effects of green tea hasstimulated the development of new processes for the extractionof the polyphenolic fraction[14,21].

The quality of polyphenol extracts and their antioxidant activity depends on the quality of the starting material (geographic origin, climatic conditions, harvesting date, storage conditions), and the technological processes involved during its manufacture.

Cite this article: Sruthi, P.S. and Nukasani, S., Review on Nutraceutical relevance of Green tea polyphenols and Microencapsulation, *Int. J. Pure App. Biosci.* **5(6):** 1515-1520 (2017). doi: http://dx.doi.org/10.18782/2320-7051.3064

In particular, extraction must take place under suitable conditions that minimize the possible alteration of tea flavanols, which are especially prone to epimerization and oxidative oligomerisation[24,29]. Green tea catechins (GTC) are also unable to sustain in the alkaline conditions. Hence, in order to protect catechins against the degrading effects of the environment they can be microencapsulated into different wall materials according to its suitability and marketability using spray drying technique. Microencapsulation is a technique to protect bioactive ingredients from adverse environmental conditions and for controlled release at targeted site.

Health Benefitsof Green Tea

Green tea has been considered as a medicine and as a healthful beverage since ancient times. The traditional Chinese medicine has recommended this plant for headaches, body aches, pains, digestion, depression, and detoxification, as an energizer and, in general, to prolong life. Green tea leaves contain three main components which act upon human health: xanthic bases (caffeine and theophylline), essential oils and especially, polyphenolic compounds. Caffeine acts mainly upon the central nervous system, stimulating wakefulness, facilitating ideas association and decreasing the sensation of fatigue. The major effects caused by caffeine are influenced by theophylline tea content. Theophylline induces hallucinogenic activity; also it promotes muscular strength and widening of blood vessels, and a much higher diuretic effect than caffeine. However, increased activity of green tea can be observed at the bronchopulmonar and respiratory level. Theophylline causes a non-specific relaxation on the bronchial smooth muscle, and respiratory stimulation is also observed. Green tea is the type of tea with the higher percentage of essential oils. However, green tea has received a great deal of attention especially due to its content of polyphenols, which are strong antioxidants and present important biological properties[12]. Numerous studies have also demonstrated that the aqueous extract of GTP possesses antimutagenic, antidiabetic,antibacterial, anti-inflammatory, and hypocholesterolemic properties. Beneficial effects especially in dental disorders such as protection against dental caries, periodental disease, and tooth loss (which may significantly affect a person's overall health) have also been described. Catechins and gallic acid have been considered to have active role in the human health among all GTP.

Bioavailability of Green Tea Catechins

The major health benefits of catechins depends not only on the amount of catechin consumed but on its bioavailability.To understand the catechin bioavailability and metabolism, it is important to evaluate their biological activity within target tissues.Compared to other catechins different species shows differences in the bioavailability of EGCG compound. EGCG is less bioavailable in humans, compared to other green tea catechins.A recent study in humans compared the pharmacokinetics of equimolar doses of pure EGC, ECG, and EGCG in 10 healthy volunteers; average peak plasma concentrations after a single dose of 1.5 mmol was 5.0 mol/L for EGC, 3.1 mol/L for ECG, and 1.3 mol/L for EGCG. After 24 h, plasma EGC and EGCG returned to baseline, but plasma ECG remained elevated. In human system, ECG has been found to be more highly methylated than EGCG and EGC, and EGCG has been found to be less reversibly combined with EGC and EC.

Stability of catechins: epimerization and degradation

Epimerization is the conversion of tea catechins to their corresponding isomers. The identified epicatechins in green tea i.e. EGCG, EGC, ECG, and EC are in cis structure. They can convert to their epimers that are non-epicatechins, i.e. GCG, GC, CG, and C, respectively[6,31]. This epimerization between pair catechins is reversible. The chemical structures of epicatechins and non-epicatechins only differ between 2R, 3R (2, 3-cis, epi-form) and 2S, 3R (2, 3-trans, nonepiform). Epimerization can occur at high temperature[29]. It has been recognized that catechins undergo epimerization at the C-2-position in hot aqueous solution. This epimerization can change the structured epicatechin to non-epi-structured catechin and vice versa. Wang *et al*[31]., reported that the concentration of catechins decreased while their isomers increased as the temperature increased.

Degradation of catechins was evident as there was a declining trend in total catechins with increasing temperature. Many researchers have found that tea catechins could convert to their corresponding epimers in traditionally brewed tea infusion and canned tea drinks during brewing, production, and storage[9,35]. Tea catechins undergo many chemical changes such as oxidation and epimerization during the course of the brewing processes. As a result, epimerization of the catechins is thought to be one of the most important reactions in the manufacture of green tea[30].

Extraction of Green Tea Polyphenols

Traditionally, green tea leaves are extracted with water. Studies have dealt with the methods of extraction of bioactivecompounds from green tea, such as microwave-assisted extraction, supercritical carbon dioxide, heat reflux extraction and Soxhlet extraction, ultrasonic extraction and so on[7,34] Ultra-high pressure extraction(UPE)is a novel technique at present, which we had successfully used to extract major catechins and polyphenols from green tea leaves[23].

Microencapsulation of polyphenols

Encapsulation is a process of entrapping one substance with another substance, resulting in the production of particles with diameters ranging from a few nm to a few mm.The substance that is encapsulated may be called the core material, the active agent,fill, internal phase, or payload phase. The encapsulating substances may bewidely known as coating, shell, membrane, wall material, carrier material, external phase or matrix. It is highly essential that the carrier material of encapsulates used in food products or processes should be food grade and also it should act as a barrier for the active agents especially with its surroundings. Microencapsulation, which has got developed almost 60 years ago, has been defined as an excellent technology of packaging solids, liquids, or gaseous materials in small amounts like sealed capsules which can release their contents at a controlled rate under specified conditions[10]. The packaged materials can be pure materials or a mixture, which are also called coated material, core material, actives, fill, internal phase or payload. On the other hand, the packaging materials are called coating material, wall material, capsule, membrane, carrier or shell, which can be made of sugars, gums, proteins, natural and modified polysaccharides, lipids and synthetic polymers[13,19]. Microcapsules are small vesicles or particulates that may range from sub-micron to several millimeters in size[11]. Much morphology can be produced for encapsulation, but two major morphologies are more commonly seen. One is mononuclear capsules, which have a single core enveloped by a shell, while the other is aggregates, which have many cores embedded in a matrix[26]. Their specific shapes in different systems are influenced by the process technologies, and by the core and wall materials from which the capsules are made. Various techniques are used for encapsulation. The steps involved in encapsulation of bioactive agents are (a) wall formation around the material to be encapsulated (b) make sure that undesired leakage does not occur (c) ensure that undesired materials are kept out[13,20]. At present the encapsulation techniques which were in use are spray drying, spray cooling/chilling, fluidized bed coating, extrusion, coacervation, liposome entrapment, inclusion complexation, centrifugal suspension separation, lyophilization, cocrystallization and emulsion, etc[2,10,13].

The prime objective of encapsulation is to protect the core material from adverse environmental conditions, such as light, oxygen and moisture, which not only leads to an increase in the shelf life of the product, but also promotes a controlled liberation of the encapsulate[27]. In the food industry, the microencapsulation technique can be chosen for multiple reasons, which have been grouped by Desai and Park[10] as follows: (i) protection of the core material from spoilage by reducing its reactivity towards outside environment (ii) reduction of the evaporation rate of the core material to the outside environment; (iii) Facilitating ease in handling through modification of the physical characteristics of the original material(iv) adjusting the release of the core material slowly over time, or at a particular time(v) to prevent an unwanted flavor or taste of the core material(vi) dilution of the core material when only small amounts are required, while achieving uniform dispersion in the host material; (vii) to help in separating the components of the mixture that would likely to react with one another. Food ingredients of acidulants, flavoring agents, sweeteners, colorants, lipids, vitamins and minerals, enzymes and microorganisms, are encapsulated using different technologies[10].

Recently, research and application of polyphenols have been areas of great interest in the functional foods, nutraceutical and pharmaceutical industries[18,25]. Polyphenols constitute one of the most numerous and ubiquitous groups of plant metabolites, and are an integral part of both human and animal diets which possess a high spectrum of biological activities, including antioxidant, anti-inflammatory, antibacterial, and antiviral functions[4,15,23]. A large body of preclinical research and epidemiological data suggests that plant polyphenols can slow the progression of certain cancers, reduce the risks of cardiovascular disease, neurodegenerative diseases, diabetes, or osteoporosis, suggesting that plant polyphenols might act as potential chemo preventive and anti-cancer agents in humans[1,18,28]. The concentrations of polyphenols that appear effective in vitro are often of an order of magnitude higher than the levels measured in vivo. The effectiveness of nutraceutical products in preventing diseases depends on preserving the bioavailability of the active ingredients[3]. This is a big challenge, as only a small proportion of the molecules remain available following oral administration, due to insufficient gastric residence time, low permeability and solubility within the gut, as well as their instability under conditions encountered in food processing and storage (temperature, oxygen, light), or in the gastrointestinal tract (pH, enzymes, presence of other nutrients), all of which limit the activity and potential health benefits of the nutraceutical components, including polyphenols[3]. The delivery of these compounds therefore requires product formulators and manufacturers to provide protective mechanisms that can maintain the active molecular form until the time of consumption, and deliver this form to the physiological target within the organism. Another unfortunate trait of polypheonls is their potential unpleasant taste, such as astringency, which needs to be masked before incorporation into food products[16]. The usage of encapsulated polyphenols in place of free compounds can overcome the drawbacks of their instability,alleviate unpleasant tastes or flavors, as well as enhance the bioavailability and half-life of the compound invivo and in vitro[2,10].

Spray drying

Spray drying technique has been practiced in the food industry since the late 1950's. Because spray drying is an economical, flexible, continuous operation, and produces particles of good quality, it is the most widely used microencapsulation technique in the food industry and is typically used for the preparation of dry, stable food additives and flavors[10]. For encapsulation purposes, modified starch, maltodextrin, gum or other substances are hydrated to be used as the wall materials. The core material for encapsulation is homogenized with the wall materials. The mixture is then fed into a spray dryer and atomized with a nozzle or spinning wheel. Water is evaporated by the hot air contacting the atomized material. The capsules are then collected after they fall to the bottom of the drier[13].

The typical shape of spray dried particles is spherical, with a mean size range of10-100μm.One limitation of the spray-drying technology is the limited number of shell materials available, and since the shell material must be soluble in water at an acceptable level[10]. Maltodextrins are widely used for encapsulation of flavours[5], which are also used for polyphenol encapsulation.

CONCLUSION

Green tea polyphenol has a great role in the world of having demand for functional foods. It can be incorporated in to the daily lifestyle of people through microencapsulating it. Spray dried polyphenol powder have the potency to utilize it in many ready to eat healthy food formulation. Polyphenol powders will surely have its rising demand among the nutraceutical products. There is a great positive future for green tea polyphenol powder if it is used in food and beverage formulations. The research should be done for effective preservation of green tea polyphenols and exploration of efficacy of various encapsulating materials other than the normally used encapsulating materials.

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