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Short communication

Characterization and storage properties of a new microencapsulation of tea polyphenols

Jingya Wang, Hongyi Li, Zhongqin Chen, Wei Liu, Haixia Chen*

Tianjin Key Laboratory for Modern Drug Delivery & High-Efficiency, School of Pharmaceutical Science and Technology, Tianjin University, Tianjin 300072, PR China

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ABSTRACT

In order to improve the stability of tea polyphenols (TP), microencapsulation was applied by using spray drying method with hydroxypropyl methylcellulose phthalate as coating material. The obtained microcapsules were further characterized on the physical properties, encapsulation efficiency, *in vitro* digestion study, storage stability and antioxidant capacity. The antioxidant activity was evaluated by 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical scavenging assay. The microcapsules were found to have a smooth surface shape with a particle size distribution of 10–200 μm by scanning electron microscopy (SEM) observation. The encapsulation efficiency of microencapsulated TP was 70.98%. Release rate of TP from microcapsules in simulated intestinal fluid had increased significantly compared with that in simulated gastric fluid ($p < 0.05$). The storage stability of TP against adverse environment (such as high temperature, excessive acid and alkaline) was also remarkably improved by microencapsulation ($p < 0.05$). The antioxidant activity of TP could be effectively protected by microencapsulation. Microencapsulation might be a better way for the storage and application of TP in food industry.

1. Introduction

Tea, derived from *Camellia sinensis* L., is one of the most popular and lowest cost global beverages owing to its attractive aroma, taste, and healthy effects (Jain et al., 2013). Depending on the degree of fermentation, tea can be categorized into three main types: green tea (non-fermented), oolong tea (semi-fermented) and black tea (full-fermented). Tea contains multiple chemical components such as polyphenols (catechins, flavonoids, proanthocyanidins), alkaloids (caffeine, theobromine, theophylline), terpenoids, amino acids, and polysaccharides (Namal Senanayake, 2013). Among these large variety of compounds, the polyphenols have been considered the most important components for health benefits with the bioactivities such as anti-tumor, anti-diabetic, anti-bacterial and antioxidant properties (Marquardt and Watson, 2014). However, polyphenols are easily deteriorated when exposed to these inappropriate conditions (heat, moisture and light) because of the presence of active phenolic hydroxyl in their molecular structure (Jayasekera et al., 2011). The storage conditions could have negatively effects on the antioxidant capacity. So, there is a growing challenge on polyphenols for protecting bioactivity from damage by some forms during processing.

Microencapsulation is an effect technology for protection of the stability and activities of polyphenols (Bakowska-Barczak and Kolodziejczyk, 2011; Çam et al., 2014). Some kinds of polyphenols had been microencapsulated and characterized in previous reports. Saénz et al. (2009) studied spray drying as a technique for stabilizing cactus pear pulp from *Opuntia ficus-indica*. Bayberry polyphenols had been microencapsulated and the stability was improved (Zheng et al., 2011). Although several plant microencapsulated polyphenols had been investigated, the preparation of tea polyphenols (TP) microcapsules still had not been reported and it was not clear whether the stability and the activities of microencapsulated TP could be improved.

In this study, the objective was to prepare microencapsulated TP and characterize storage stabilities and the changes of antioxidant activities. The spray drying method was applied for preparation of TP microcapsules using hydroxypropyl methylcellulose phthalate as wall material. The stabilities of free TP and microencapsulated TP were comparatively studied under the conditions of different pH values and temperatures. The changes of antioxidant activities *in vitro* were investigated. Moreover, the release rate of TP from microcapsules in simulated intestinal fluid and simulated gastric fluid be determined.

* Corresponding author.
E-mail address: chenhx@tju.edu.cn (H. Chen).

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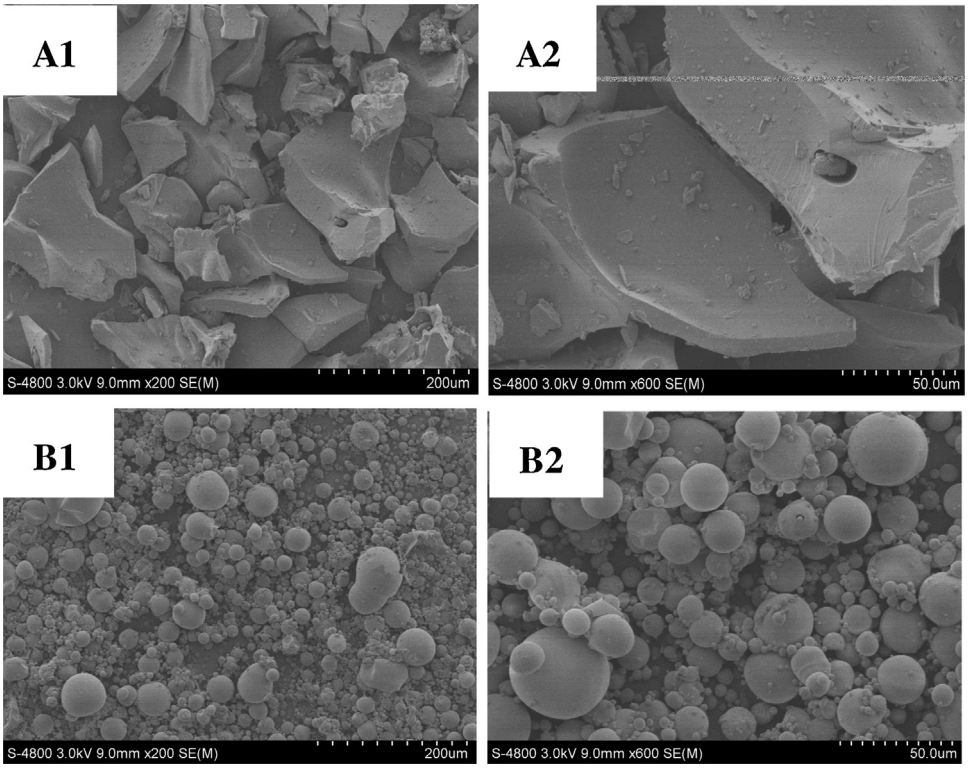

Fig. 1. Scanning electron micrographs at 200 (1) and 600 (2) fold magnification of FTP and MTP (A: FTP; B: MTP). FTP: Free tea polyphenols; MTP: Microencapsulated tea polyphenols.

2. Materials and methods

2.1. Preparation of wall/core materials for the microcapsules

Hydroxypropyl methylcellulose phthalate (HPMCP) was used as the wall materials purchased from Tianjin Jiangtian Chemical Co., Tianjin, China. HPMCP solution (4%) was prepared with water. TP were used as core materials that were extracted from green coarse tea (bought from Tianjin local tea market). Extraction of TP was performed according to our previous studies (Chen et al., 2008). All chemicals used were of analytical grade.

2.2. Preparation of microcapsules by applying spray-drying technique

Preparation of TP microcapsules was performed according to Wang et al. (2014). The TP samples and SDS (2%) were added into HPMCP solution. The solution was dispersed until an emulsified dispersion system was formed and then spray-dried. The TP microcapsules were collected.

2.3. Physical properties of microcapsules

2.3.1. Morphological properties

The free TP or the microencapsulated TP was placed on one surface of two-sided adhesive tapes that was fixed to the sample support, coated with gold under vacuum condition and then observed on a scanning electron microscope (SEM, Philips XL-30) (Zheng et al., 2011). Each sample was observed with 200 and 600 fold magnification at an accelerating potential of 20 kV during micrography.

2.3.2. Size analysis

The size of the microencapsulated TP was expressed by the average particle diameter, determined by scanning electron microscope (SEM) observation.

2.4. Determination of encapsulation efficiency of microencapsulated TP

The encapsulation efficiency of microencapsulated TP was calculated following the method of Yan et al. (2014). The TP content on the surface of the microcapsules and the total TP of microcapsules were determined by the Folin-Ciocalteu method described by Zheng et al. (2011). All the tests were carried out in triplicate.

2.5. In vitro study of free and microencapsulated TP under simulated gastric and simulated-intestinal conditions

The stabilities of free TP and microencapsulated TP were evaluated in simulating gastric fluid (SGF) and intestinal fluid (SIF). SGF and SIF were prepared according to the description of Hsieh et al. (2009) with some modifications. SGF consisted of 5.0 g pepsin in 8.2 mL HCL, stirred and then diluted to a constant volume of 500 mL. SIF consisted of 5.0 g pancreatin, 3.4 g KH_2PO_4 in 250 mL distilled water, simulated into intestinal solutions as pH of 6.8 by 4% NaOH and then diluted to a constant volume of 500 mL. The microencapsulated TP in distilled water were incubated at $37 \pm 0.5\,^{\circ}C$ with the sample collected at 10, 20, 60, 120, 180, 240 and 300 min, by shaking at $200 \times g$ and $300 \times g$ for 1 h. All the experiments were made in triplicate.