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A review of microencapsulation methods for food antioxidants: Principles, advantages, drawbacks and applications

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ABSTRACT

Bioactivities and numerous health benefits against a number of oxidative stress related diseases have been attributed to the role of dietary antioxidants. The development of physical (spray drying, lyophilization, supercritical fluid precipitation and solvent evaporation), physico-chemical (coacervation, liposomes and ionic gelation) and chemical encapsulation techniques (interfacial polymerization and molecular inclusion complexation) enable to obtain healthier and acceptable bioactive compounds. This review focuses on the impacts of microencapsulation techniques on the encapsulation characteristics of food antioxidants. Additionally, this study also provides detailed information on the principles, effective parameters, advantages, disadvantages and applications of microencapsulation techniques.

1. Introduction

Antioxidants as food preservatives have gained an increasing attention as they prevent foods from deterioration occured through oxidation, reduce loss of nutritional value and energy contents, allow freshness by ensuring flavours, odours, colour pigments, taste and texture. Consequently, numerous health benefits in reducing cancer, cardiovascular and neurological diseases as well as anti-inflammatory, antibacterial, anti-allergic, anti-hypertensive, antiviral and skin wound healing effects have been attributed to the role of dietary antioxidants (Alvarez-Suarez et al., 2016; Ballesteros, Ramirez, Orrego, Teixeira, & Mussatto, 2017; Giampieri et al., 2013). Various food antioxidants have been classified into different categories based on their chemical structure and functions: water soluble bioactives including citrates, norbixin, betalains, most of the phenolics, flavanoids and anthocyanins, and lipid soluble components such as carotenoids, tocopherols, terpenoids and vitamin E (Carocho, Morales, & Ferreira, 2017).

The relevant antioxidant activities of bioactive substances may be hampered due to their degradation triggered by light, oxygen, temperature, moisture and existence of unsaturated bonds in the molecular structures. Thus, microencapsulation with an appropriate carrier is an alternative technology for enhancing the storage and enviromental stability of bioactives as well as giving an advance to mask off-flavour, bitter taste and astringency of polyphenols (Ballesteros et al., 2017). Accordingly, investigating the effects of microencapsulation techniques on food antioxidants is of great importance.

Microencapsulation is a process of packaging solids, liquids, or gaseous materials as active material with a continuous film as a coating to form capsules in micrometer to millimeter in size (Tyagi, Kaushik, Tyagi, & Akiyama, 2011). Microencapsulation techniques are classified into three groups (Tyagi et al., 2011): (i) physical methods such as spray drying, lyophilization, supercritical fluid precipitation and solvent evaporation; (ii) physico-chemical methods including coacervation, liposomes and ionic gelation; (iii) chemical methods such as interfacial polymerization and molecular inclusion complexation (See Table 1).

The aim of the present review is to provide a critical evaluation based on the effects of different microencapsulation technologies on food antioxidants. In order to achieve this purpose, studies investigating the effect of encapsulation on the antioxidant capacity, stability, solubility and retention of bioactive compounds were covered. Furthermore, the principles, effective parameters in the methodology, advantages, disadvantages and potential application fields of each method are highlighted.

2. Physical methods

2.1. Spray drying

Spray-drying is an encapsulation technique related with the

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Table 1
Effects of microencapsulation techniques on the food antioxidants.

Applied Technique	Core material	Wall material	Results	Reference
Physical techniques				
Spray drying	Blueberry juice	Inulin and maltodextrin	Inulin based particles presents 5.1 and 1.5% of resveratrol and quercetin 3-d-galactoside, respectively, whereas, maltodextrin based particles include 21.1 and 28.5%.	(Araujo-Díaz et al., 2017)
	Pitanga juice	High Performance Agave Fructans and High Degree of Polymerisation Agave Fructans and maltodextrin	The highest DPPH radical scavenging activity (59.53 mmol ET/100 g solid) with maltodextrin-based microcapsules (wall/core material ratio of 6/1)	(Ortiz-Basurto et al., 2017)
	Blueberry polyphenols	Wheat flour, chickpea flour, coconut flour and soy protein isolate	90% Retention of phenolic content by soy protein isolate after 16 weeks of storage at 4 and 20 °C	(Correia et al., 2017)
	Orange peel extract	Whey protein isolate	95% Retention for both total phenolic content and DPPH radical scavenging activity	(Sormoli and Langrish, 2016)
	Amla juice	Maltodextrin	Better retention of total phenolic content and DPPH radical scavengin activity with 125 °C drying temperature and 5% maltodextrin concentration	(Mishra et al., 2014)
	Pomegranate juice	Maltodextrin	Decrease in anthocyanin content with increasing maltodextrin concentration	(Jafari et al., 2017)
	Beetroot juice	Maltodextrin	The highest betain retention (70.46%) with 15% maltodextrin Increasing DPPH scavenging activity (56.55 and 67.76%)	(Bazaria and Kumar, 2016)
	Coffee phenolics	Maltodextrin, gum arabic and the mixture of both	Better retention with maltodextrin regarding flavonoid content (7.88 mg QE/100 ml) and total antioxidant activity (380.25 mg α-TOC/100 ml)	(Ballesteros et al., 2017)
	Guava	Maltodextrin and β-cyclodextrin	3% degradation in β-cyclodextrin based microparticles 2.5–3 times lower antioxidant potential of spray dried extract compared with concentrated extract	(Fernandes et al., 2014)
	Grape fruit	Gum Arabic and bamboo fiber	58% retention in phenolic content 92–94% retention in ascorbic acid	(Agudelo et al., 2017)
Lyophilization	Blueberry juice	Hydroxypropyl-β-cyclodextrin, β-cyclodextrin, maltodextrin	Higher retention values for HP-β-CD and β-CD, respectively of 105.21 and 104.55 μmol/L TE/g with ABTS, 1.83 and 1.80 mmol/L TE/g with DMPD, 79.70 and 67.28 mmol/L TE/g with FRAP	(Wilkowska et al., 2016)
	Green tea polyphenols	Maltodextrin, β-cyclodextrin, combination of both	Enhanced antioxidant activity (IC_{50} value 54.77–60.26 μg/ml)	(Pasrija et al., 2015)
	Gallic acid	Chitosan, β-cyclodextrin, xanthan	There were no significant effect	(da Rosa et al., 2013)
	Bayberry polyphenols	Ethyl cellulose	Increased free radical inhibition	(Zheng et al., 2011)
	Blackberry	Maltodextrin 10 and 20 DE	76% retention with maltodextrin 10DE 68% retention with maltodextrin 20DE	(Yamashita et al., 2017)
	Saffron petal	Cress seed gum, Gum Arabic	33% reduction in anthocyanin content of un-encapsulated extract No significant change after microencapsulation as well as storage of dried powders	(Jafari et al., 2017)
	Black glutinous rice bran anthocyanins	Black glutinous rice maltodextrin DE10, 20 and 30	~71.96% anthocyanin retention in the freeze dried powders Higher retention with black glutinous rice maltodextrin DE20 than commercial DE10	(Laokuldilok and Kanha, 2015)
	Garcinia fruit	Whey protein isolate, maltodextrin and the combination of both	Higher free (above 85%) and net (above 90%) HCA recovery	(Ezhilarasi et al., 2013)
	Cherry juice	Maltodextrin and arabic gum	Enhanced monomeric anthocyanin content with freeze-dried encapsulated juice powder (67.5 mg/100 g) After 33 days of storage at 38 °C, 90% retention for freeze-dried powder	(Sanchez et al., 2015)

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