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Review

Vegetable proteins in microencapsulation: A review of recent interventions and their effectiveness

Alla Nesterenko[a,b], Isabelle Alric[a,b], Françoise Silvestre[a,b], Vanessa Durrieu[a,b,*]

[a] Université de Toulouse, INP-ENSIACET, LCA (Laboratoire de Chimie Agro-industrielle), F-31030 Toulouse, France
[b] INRA, UMR 1010 CAI, F-31030 Toulouse, France

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ABSTRACT

Proteins from vegetable seeds are interesting for research at present because they are an abundant alternative to animal-based sources of proteins and petroleum-derived polymers. They are a renewable and biodegradable raw material with interesting functional and/or physico-chemical properties. In microencapsulation, these biopolymers are used as a wall forming material for a variety of active compounds. In most cases, two techniques of microencapsulation, spray-drying and coacervation, are used for the preparation of microparticles from vegetable proteins. Proteins extracted from soy bean, pea and wheat have already been studied as carrier materials for microparticles. These proteins could be suitable shell or matrix materials and show good process efficiency. Some other plant proteins, such as rice, oat or sunflower, with interesting functional properties could be investigated as potential matrices for microencapsulation.

Contents

* Corresponding author at: Université de Toulouse, INP-ENSIACET, LCA (Laboratoire de Chimie Agro-industrielle), F-31030 Toulouse, France.
Tel.: +33 5 34 32 35 09; fax: +33 5 34 32 35 97.
E-mail address: Vanessa.Durrieu@ensiacet.fr (V. Durrieu).

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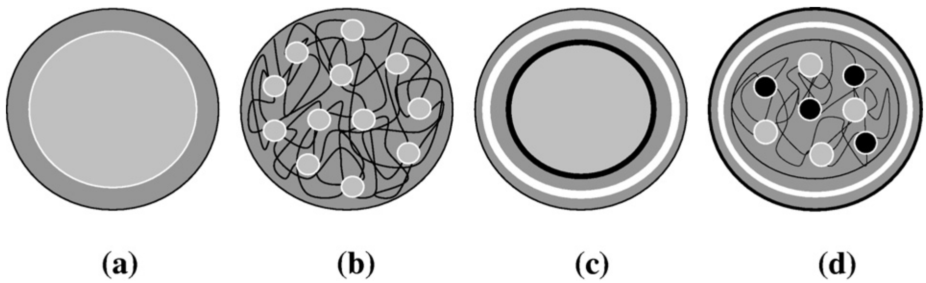

Fig. 1. Different morphologies of microparticles obtained by microencapsulation: (a) microcapsule, (b) microsphere, (c) multilayer microcapsule and (d) multishell and multicore microsphere.

1. Introduction

Microencapsulation consists of the isolation of active substances (in the liquid, solid or gas state), to obtain products with spherical form and micrometric size, in which the active material or core, is shielded by a membrane from the surrounding environment. This technique can be applied for different purposes: protecting sensitive substances from the surroundings, development of controlled release properties, masking of unpleasant taste and odor of the substances, dilution of core material when it must be used in very small amounts or transformation of liquid compounds into mobile solids. Microencapsulation allows the creation of a physical barrier between the core and wall materials and the protection of sensitive ingredients (flavors, antioxidants, polyunsaturated oils, vitamins, drugs, etc.) from the external medium, particularly, moisture, pH and oxidation. The release of microparticle content at controlled rates can be triggered by shearing, solubilization, heating, pH or enzyme action. This technology has different applications in the food, biomedical, pharmaceutical and cosmetic industries as well as in agriculture and catalysis (Dubey et al., 2009). The structure of microparticles is generally classified into microcapsules with a single core surrounded by a layer of wall material; microspheres with the core dispersed in a continuous matrix network and more complex structures such as multilayer microcapsules or multishell microspheres (Fig. 1). Various processes may be used to produce encapsulated ingredients (Augustin et al., 2006; Benita, 2006; Dubey et al., 2009; Gouin, 2004; Munin and Edwards-Lévy, 2011; Jyothi et al., 2010): spray-drying, spray-cooling/chilling, fluidized bed, coacervation/phase separation, gelation, solvent evaporation, supercritical fluid expansion, interfacial polymerization (polycondensation), emulsion polymerization and extrusion. Choice of microencapsulation technique for a particular process will depend on the size, biocompatibility and biodegradability of microparticles needed, the physico-chemical properties of core and coating, the microparticles' application, the proposed mechanism for active core release, and on the process costs.

Wall material particularly affects the microparticles' stability, the process efficiency and the degree of protection of the active core. Materials commonly used as carriers in the makeup of encapsulated ingredients, are synthetic polymers and co-polymers, and bio based materials such as carbohydrates, fats, waxes, and animal and plant derived proteins. Petroleum derived polymers commonly used in pharmacy and medicine as a matrix for microparticle preparation are polystyrenes, polyamides, polyurethanes, polyacrylates, phenolic polymers, and poly(ethylene glycols) (Dubey et al., 2009). Functionalization of polymeric chains makes it possible to obtain microparticles with new properties, different from those obtained with other wall materials, for example resistance to the action of chemical agents (Patel et al., 2010). Polysaccharides studied as a matrix for microencapsulation are starches (Jeon et al., 2003; Murúa-Pagola et al., 2009), maltodextrin (Krishnan et al., 2005; Saénz et al., 2009; Semyonov et al., 2010), gum Arabic (Kim et al., 1996; Shaikh et al., 2006), pectin (Drusch, 2007; Gharsallaoui et al., 2010), chitosan (Higuera-Ciapara et al., 2004; Pedro et al., 2009), and alginates (Yoo et al., 2006; Huang et al., 2010; Wikstrom et al., 2008). The major advantages of these biopolymers are their good solubility in water and low viscosity at high concentrations, compared to proteins. Often carbohydrates are mixed with proteins (Augustin et al., 2006; Ducel et al., 2004b; Mendanha et al., 2009; Pereira et al., 2009; Pierucci et al., 2006, 2007; Yu et al., 2007) to improve the emulsifying and filmogenic properties during microencapsulation. Furthermore, protein–carbohydrate conjugates covalently cross-linked by the Maillard reaction had shown interesting functional properties (Augustin et al., 2006; Rusli et al., 2006). Various lipophilic substances such as glycerides, oils, phospholipids, carotenoids and waxes are also used as carrier materials in microencapsulation (Eldem et al., 1991; Lee et al., 2003; McClements et al., 2007; Muller et al., 2002; Patel et al., 2010). They permit barrier creation for the protection of sensitive ingredients against moisture, plus their transport in aqueous media.

Proteins extracted from animal derived products (whey proteins, gelatin, casein) and from vegetables (soy proteins, pea proteins, cereal proteins) are widely used for encapsulation of active substances. These natural polymers present several advantages: biocompatibility, biodegradability, good amphiphilic and functional properties such as water solubility, and emulsifying and foaming capacity. The use of vegetable proteins as wall-forming materials in microencapsulation, reflects the present "green" trend in the pharmaceutical, cosmetics and food industries. In food applications, plant proteins are known to be less allergenic compared to animal derived proteins (Jenkins et al., 2007; Li et al., 2012). For these reasons, over the past few years, the development of new applications for plant products rich in proteins has became an increasingly interesting area for research. For the last decade, the protein ingredient industry has been turning towards plants as a preferred alternative to animal-based sources, e.g. in vegetarian diets, due to increased consumer concerns over the safety of animal-derived products (Jiménez-Yan et al., 2006; Sawashita et al., 2006; Choi et al., 2010). Currently, the widespread presence of microparticles based on animal proteins, contrasts with the very limited use of plant proteins in industry. This tendency should be reversed in coming years.

Vegetable proteins consist of several fractions: the major fraction is glutenin, soluble in alkaline water solutions; the globulin fraction, soluble in salt solutions, followed by the albumin and prolamin, fractions soluble in water and ethanol, respectively (Osborne, 1909). Among vegetable proteins used as a wall material in microencapsulation, we find mainly soy protein isolate, pea protein isolate and cereal proteins. Soybean proteins have functional properties suitable for microencapsulation, such as solubility, water and fat absorption, emulsion stabilization, gelation, foaming, plus good film-forming and organoleptic properties (Franzen and Kinsella, 1976). Soy glycinin and conglycinin are somewhat