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Use of proteins for the delivery of flavours and other bioactive compounds

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ABSTRACT

The purposes of this review are: 1) to provide insights into how proteins are used for the encapsulation of food ingredients; and 2) evaluate their performance in this role.

Proteins possess functional properties that are critical to the successful spray drying and coacervation processes. In spray drying, they serve as excellent emulsifiers. The initial step of any spray drying process is the formation of an emulsion: emulsification serves to distribute a bioactive material throughout the wall material on drying. For complex coacervation, proteins serve as one half of the wall material, that is, serving as a positively charged food polymer which forms ionic bonding to a negatively charged food polymer most commonly a food gum. In terms of performance, high encapsulation efficiency and stability against oxidation on storage are key roles proteins must offer. This review considers encapsulation performance of proteins for flavorings as a separate section from nonvolatile bioactives (e.g. colorants, edible oils, or other bioactives). Due to the chemical reactivity of proteins, they find limited use for the encapsulation of flavorings (by spray drying or coacervation). However, they can be excellent for the encapsulation of other food ingredients. While in spray drying the use of proteins can be effectively avoided by using a modified starch or a gum such as gum acacia for emulsification, coacervation offers little alternative to proteins as a positively charged polymer forming part of the coacervate wall (chitosan is the only alternative). Since proteins cannot easily be avoided in coacervation, this process may be used for the encapsulation of ingredients other than flavorings.

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1. Introduction

The current trend of minimizing the use of artificial substances in our foods has placed great emphasis on the use of encapsulation techniques for the delivery of fragile or labile ingredients such as flavourings, natural colorants, phytosterols, edible oils, or other bioactive substances. Historically the functions of these natural ingredients were being met through very robust artificial components: color is a good example. The FD&C colors have been used broadly in the food industry for many years. These materials are largely unaffected by food composition or environmental considerations. The natural materials that are being used to replace them are largely very unstable being prone to oxidation which is enhanced by light exposure (e.g. carotenoids). Encapsulation is being called on as a protection mechanism to permit the use of these natural materials in our foods and thus, satisfy a consumer need.

The objective of this paper is to provide an updated overview of how proteins are being used to deliver flavours and other natural bioactive substances to consumers via encapsulation. Note that it is limited to their delivery in dry form and does not include the potential of delivering these materials as emulsions. For details on understanding some of the effects described in this paper, the following articles are suggested reading (Bakry et al., 2016; Drusch, Serfert, Scampicchio, Schmidt-Hansberg, & Schwarz, 2007; Drusch et al., 2009a; Reineccius & Yan, 2016; Ubbink, 2016).

2. Encapsulation techniques

Numerous techniques are used to encapsulate ingredients used in the food industry (Table 1). The preferred process depends largely upon the ingredient to be encapsulated and its end use. Thus, while a specific process may predominate in a limited ingredient area, spray drying is by far the process used to produce the majority of food ingredients.

Spray drying is widely available, uses relatively inexpensive “natural” ingredients, produces a product that performs reasonably well and is reasonable in cost. Relevant to this publication, proteins find application as encapsulation materials for spray drying.

2.1. Spray drying

The equipment used in spray drying is shown in Fig. 1. Briefly, one dissolves the intended capsule material (for example, a protein, gum acacia, modified starch, or a maltodextrin) in water in a mix tank. The active material (flavouring, colorant, fish oil, etc.) is added and then emulsified/homogenized into the slurry. The emulsion is pumped to the top of the dryer and is atomized into a hot air stream where the material is dried very quickly. The air and powdered material are separated in the cyclone. The moist, hot air is vented outside the building and the powder is packaged for sale (for details on the process, see Masters, 1991, p. p 725).

Table 1
Processes used for the encapsulation of food ingredients.

Spray drying	Freeze-drying
Extrusion	Plating
Molecular inclusion (cyclodextrins)	Prilling (spray chilling)
Coacervation	Liposomes
Matrix solidification	Drum drying
Tray drying	

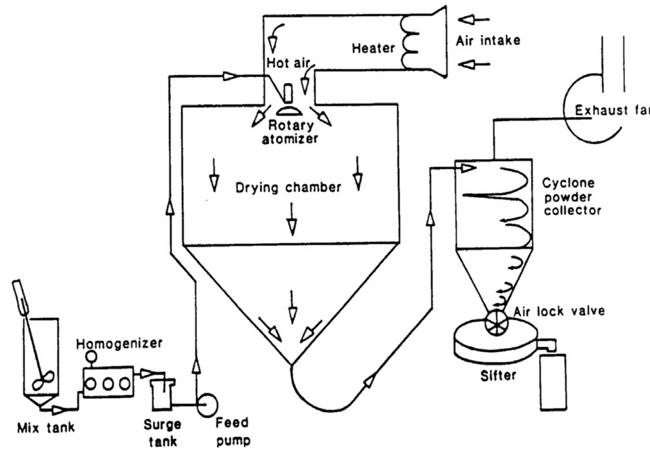

Fig. 1. Schematic of a spray dryer.

2.2. Coacervation

A second encapsulation process that may use proteins for encapsulation is complex coacervation (Timilsena, Wang, Adhikari, & Adhikari, 2017; Xiao, Liu, Zhu, Zhou, & Niu, 2014). Complex coacervation is a process whereby an electrically charged food polymer is dispersed in Water and then an active ingredient is added with stirring to form a course emulsion. A second food polymer of opposite electrical charge (upon pH adjustment) is then added to the emulsion. The two polymers will come together at the emulsion particle surface and through ionic bonds, form a complex forming a shell around the active material. While there are a large number of food hydrocolloids that carry a negative charge, proteins or chitosan are essentially the only food polymers that provide a positive charge. Proteins are preferred over chitosan and thus, are generally used in encapsulation via complex coacervation. While at this time coacervation sees limited use in the food industry, its use is expected to increase. Coacervation offers some advantages over spray drying. They are:

- High encapsulation efficiency (that may not be true for flavouring materials)
- High loads are possible due to core and shell structure (up to 90%)
- Gentle processing conditions (low temperatures)
- Good protection against oxidation
- Controlled release (diffusion) is possible if particle wall is cross-linked

Weaknesses will be discussed later when the process is elaborated upon in greater detail.

3. Proteins and encapsulation

Proteins find substantial use in the encapsulation of certain food ingredients (for example, fats, oils, natural colorants, and phytosterols). Proteins are excellent emulsifiers: both spray drying and coacervation require the formation of an emulsion as a first step in the process. Proteins are popular with the consumer today and thus, they have a very positive consumer image. As noted earlier, in the case of coacervation, proteins are generally the choice for the positively charged polymer. The following sections will discuss literature examples of using proteins for encapsulation via spray drying and coacervation.

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