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## Microencapsulation techniques and its application in food industry

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### Abstract

Microencapsulation is defined as a process in which tiny particles or droplets are surrounded by a coating or embedded in a homogeneous or heterogeneous matrix, to give small capsules with many useful properties. It is a technique by which liquid droplets, solid particles or gas compounds are entrapped into thin films of a food grade microencapsulating agent. Microencapsulation is a smart manner of improving the performance of products. By using this technology, an active of interest can be isolated and kept unmodified for extended periods of time. This technique has been employed in a diverse range of fields from food processing, chemicals and pharmaceuticals to cosmetics and printing. For this reason, widespread interest has developed in microencapsulation technology. There were several methods for undergoing the process of microencapsulation like spray drying, spray cooling, spray chilling, fluidised bed coating, Pan coating etc. All these methods were discussed briefly in this review.

**Keywords:** Microencapsulation, pharmaceuticals, spray drying, fluidised bed coating, pan coating

### Introduction

Gharsallaoui *et al.* [9], stated that Microencapsulation is a technique by which liquid droplets, solid particles or gas compounds are surrounded by a coating, or embedded in a homogeneous or heterogeneous matrix, to give small capsules with many useful properties under specific conditions. It can provide a physical barrier between the core compound and the other components of the product. Microencapsulation is a smart manner of improving the performance of products. An active of interest can be isolated and kept unmodified for extended periods of time by using this technology. Nowadays, microcapsules technique is found in a huge variety of products and applications ranging from insulation technologies for houses to smart textiles and agricultural products as well as consumer products like food, house and personal care products.

Microencapsulation has many applications in food industry such as to protect, isolate or control the release of a given substance which is of growing interest in many sectors of food product development. Microencapsulation procedure was discovered by Dutch chemist H.G. Bungenberg de Jong, in the year 1932. The first commercial product using the technique of microencapsulation was launched by NCR of American in 1953. The technique of microencapsulation was not a new technology for food processing industry and by the history it was introduced in the mid of 20th century. One of the largest food applications is the encapsulation of flavours.

Abbas *et al.* [1] have summarized the importance and benefits of microencapsulation technology in the food industry, based upon a variety of studies (Angelich, 2005; M.A. Augustin & Sanguansri, 2007; Dziezak, 1988; F. Gibbs, 1999; Gouin, 2004; Madene, Jacquot, Scher, & Desobry, 2006; Ren, Donald, & Zhang, 2007; Risch Sara, 1995; Shahidi & Han, 1993; Yuliani, Bhandari, Rutgers, & D'Arcy, 2004). Nedovic *et al.* [15], have studied and stated that food-grade cores and encapsulant matrices are desired for designing encapsulated ingredients that are intended for incorporation into food products. Mourtzinos *et al.* [14], observed that this technology appears to be a useful tool to protect sensitive food ingredients from degradation.

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## Microencapsulation techniques

### Spray drying

Spray drying is the most common microencapsulation technique used in food industry due to its low production costs, simplicity, ease of scaling up, and ability to produce micro particles with good properties for several uses. Subsequently, spray drying has become the most important commercial process for making dry flavourings. Vitamins, minerals, colorants, fat and oil flavour, aroma compounds, oleoresins and enzymes have been encapsulated using this technique. It is an economical, as well as an effective method for protecting materials. The particle size in spray drying ranges between 10 - 50  $\mu\text{m}$  and this process produces good quality particles.

An emulsion is prepared by dispersing the core material, usually an oil or active ingredient immiscible with water; into a concentrated solution of wall material until the desired size of oil droplets are attained. Estevinho *et al.* [8], observed that the water portion of the emulsion is evaporated, yielding dried capsules of variable shape containing scattered drops of core material. Saenz *et al.* [18], studied the Microencapsulation by spray drying of bioactive compounds from cactus pear, the results mainly highlighted that the core materials like bio active compounds of pulp and ethanoic extracts of cactus pear were encapsulated using maltodextrin or inulin. Pellicer *et al.* [16], stated that water removal by spray drying ensures the microbiological quality and facilitates the transport, dosing, and storage of the obtained products.

### Air-suspension method

The air suspension technique involves the dispersion of the core materials in a supporting air stream and the spraying of coating material in the air suspended particles. The moving air stream suspends the particles on an upward within the coating chamber. The design of the coating chamber and its operating parameters should be in such a way that could affect the flow of the particles through the coating zone of chamber, where a coating material (polymer solution) is applied to the moving particles. As the moving particles passed through the coating zone repeatedly, the core material receive more of coating material. The cyclic process is repeated about several times depending on the desired coating thickness or whether the particles of core materials are thoroughly encapsulated. The encapsulated product is air dried. The rate of drying are directly depends on to the temperature of the supporting air stream. Bansode *et al.* [3], observed that the process variables that can affect the process are concentration of the coating material, solubility, surface area, density, melting point, volatility of the core material, application rate of coating material, temperature of air stream and the amount of air required to fluidize the core material.

### Coacervation Method

In this process the core material is dispersed in the solution of coating material. The core material should not react or dissolve in solvent of coating material (maximum solubility is 2%). The particle size is defined by dispersion parameters, such as stirring speed, stirrer shape, surface tension and viscosity. The particle size range varies from 2 $\mu\text{m}$  - 1200 $\mu\text{m}$ . Coacervation starts with a change of the pH value of the dispersion, e.g. by adding  $\text{H}_2\text{SO}_4$ , HCl or organic acids. The result is a reduction of the solubility of the dispersed phase (shell material). The shell material (coacervate) starts to precipitate from the solution. The shell material forms a continuous coating around the core droplets. The shell

material is cooled down to harden and forms the final capsule. Hardening agents like formaldehyde can be added to the process. The microcapsules are now stable in the suspension. The suspension is then dried in a spray dryer or in a fluidized bed dryer.

### Interfacial polycondensation

Marison *et al.* [13], stated that Interfacial polymerization or polycondensation technique has been applied to the microencapsulation of a wide range of core materials, which includes aqueous solutions, water-immiscible liquids and solids. Solids can be encapsulated by interfacial polymerization reactions, although the polymerization chemistry differs from the encapsulation of liquids. This technique is one in which two monomers, one oil-soluble and other water-soluble, are used and a polymer is formed on the droplet surface. This process brings the two reactants together at the interface of the dispersed and continuous phases in emulsion system. The various polymeric materials that are used to prepare microcapsules by this technique are polyurea, polyamide, polysulfonamide, polycarbonate or polyurethane, polyester. The main disadvantage of this technique is that the reagent dissolves in the core material which leads to the chemical reaction of reagent with core material.

### Pan coating method

The pan coating process, widely used in the pharmaceutical industry, is among the oldest industrial procedures for forming small, coated particles. Torrado and Augsburgers [20] stated that Pan coating method is useful for coating solids and to obtain final particles of a size between micrometers and a few millimetres, which can be defined as pellets. In this method particles are tumbled in a pan while the coating material is applied slowly. With respect to microencapsulation, solid particles greater than 600  $\mu\text{m}$  in size are generally considered essential for effective coating. In practice, the coating is applied as a solution or as an atomized spray to the desired solid core material in the coating pan. Usually, to remove the coating solvent, warm air is passed over the coated materials as the coatings are being applied in the coating pans. In some cases, final solvent removal is accomplished in drying oven.

### Centrifugal Extrusion Method

Liquids are encapsulated using a rotating extrusion head containing concentric nozzles. In this process, a jet of core liquid is surrounded by a sheath of wall solution or melt. As the jet moves through the air it breaks, into droplets of core, each coated with the coating material solution. While the droplets are in flight, molten coating material may be hardened or a solvent may be evaporated from the coating material solution. Since most of the droplets are within  $\pm 10\%$  of the mean diameter, they land in a narrow ring around the spray nozzle. Hence, if needed, the capsules can be hardened after formation by catching them in a ring-shaped hardening bath.

### In situ polymerization

Ko *et al.* [11], stated that in situ formation of a hydrogel has been recognized for its potential biomedical and biotechnological applications including controlled-release drug delivery, three-dimensional (3D) cell culture, and injectable tissue engineering, since it is a simple method. Lin *et al.* [12], studied that Hydrogels are 3D polymeric networks with high water content that remain insoluble in aqueous

solutions because of chemical or physical cross linking of individual polymer chains. Hou *et al.* [10], observed that to produce hydrogels, bioactive compounds or cells are premixed in an aqueous solution and injected to a target site, to form a hydrogel depot through a sol-to-gel transition mechanism. This sol-gel transition can be generated by changing the environmental conditions including pH, temperature, light, and ionic strength.

#### Application of Microencapsulation in the food industry

Borgogna *et al.* [4], stated that the food industry utilizes functional ingredients to improve flavor, colour, and texture properties and to extend the shelf-life of food products. Ingredients that have functional health benefits, such as antioxidants and probiotics are of great interest. However, most of these ingredients have low-stability and are easily decomposed by environmental factors. Thus, Microencapsulation is one way for the preparation of high-stability bioactive compounds. In recent years, there has been a great deal of research on the production of high efficiency microcapsules and their applications in the food industry. The

#### Dairy products

Several researches have been conducted on the application of microencapsulation technology in dairy industry on the production of dairy products of daiChampagne *et al.* [6], evaluated the effects of microencapsulation by the spray-drying technique on the stability of probiotic bacteria in ice cream. Recently, several functional ice creams have been produced by adding probiotic bacteria. However, processing and storage conditions affect the viability of probiotic bacteria. Ahmadi *et al.* [2], observed that microencapsulation has been used to enhance the survival of probiotic bacteria. The results showed that the encapsulated probiotic bacteria had higher survival rates compared to the non-encapsulated culture.

#### Baked goods

Rocha *et al.* [17], produced microcapsules of lycopene by spray-drying, using a modified starch as the encapsulating agent. The functionality of microcapsules was determined by applying them to cake. Lycopene is a carotenoid present in several fruits and vegetables and is widely used as a red food colorant. Nevertheless, lycopene is easily decomposed by oxidation during the storage process, because of its high number of conjugated double bonds. In this study, microencapsulation was expected to increase the stability of lycopene. They observed that cake made with microcapsules was more pigmented than standard cake.

#### Beverages

Burin *et al.* [5], evaluated the stability of anthocyanin, which was encapsulated within different carrier agents in an isotonic soft drink system. Anthocyanins are water-soluble pigments obtained from plants. These pigments are generally used as colorants in foods and drinks, because they have high colorant power, low toxicity, and high water solubility. In their study, the spray-drying technique was used to encapsulate anthocyanins originated from Cabernet Sauvignon grapes. The results indicated that the obtained microcapsules presented uniform particle sizes and a spherical surface. Moreover, a combination of maltodextrin (MD) and gum Arabic (GA) resulted in increased protection of the anthocyanin pigments.

#### Meat and poultry

Many studies have reported that probiotic organisms have poor survival in fermented foods. To improve the viability of bacterial cells, microencapsulation technique was used to retain them within a protective polymer membrane or matrix. Serna-Saldivar *et al.* [19], examined the shelf life of bread enriched with DHA and microencapsulated fish oil, the results showed that the development of o-flavors occurred more quickly in the breads containing liquid fish oil. Microencapsulation of omega-3 fatty acids from fish oil could be used for the enrichment of pre-fried frozen meat products with fish oil, improving the oxidative shelf-life and preserving the sensory quality characteristics of the enriched products. Comunian *et al.* [7], evaluated the effect of encapsulated ascorbic acid on physicochemical and sensory stability of chicken frankfurters. Ascorbic acid is a natural antioxidant derived from fruits and vegetables. However, it is very unstable. It is easily decomposed by various factors including, heat, light, high oxygen concentration, and high water activity. Ascorbic acid is commonly used in frankfurters to replace sodium erythorbate. Hence, this study aimed to encapsulate ascorbic acid in frankfurters, because this technique allows for the incorporation of an effective antioxidant with vitamin functionality and improves stability of the product. The results showed that it was possible to produce frankfurters with acceptable sensory characteristics, when using ascorbic acid as an antioxidant.

#### Reasons for Microencapsulation

- The primary reason for microencapsulation is to increase the stability and life of the product being encapsulated.
- This technique can be used for converting liquid drugs into a free flowing powder.
- Microencapsulation can be used for the stabilization of drugs, which are sensitive to moisture or light, oxygen.
- This technique prevents the incompatibility between the drugs.
- For the reduction of toxicity and GI irritation many drugs have been microencapsulated.
- Microencapsulation prevents the drugs, which are volatile in nature and vaporize at room temperature.
- This technique has been useful for those drugs which have the toxicity at lower pH.

#### Conclusion

Encapsulation is an effective method to cover an active compound with a protective wall material and thus, offers numerous advantages. Microencapsulated Foods and other substances have wide applicability, being an effective and extremely important tool in the preservation of various microorganisms, nutritional components, enzymes, dyes, etc., protecting food and other products from the most aggressive processing methods. Each new application in microencapsulation provides a fresh challenge. Solving these riddles requires skill, experience and the mastery of many different technologies. By developing the new approaches and with the advanced strategies for stabilization of food ingredients, we will be able to improve the nutritional properties and health benefits of food compounds.

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