

## EMERGING TECHNIQUES OF MICROENCAPSULATION AND ITS APPLICATION IN FOOD INDUSTRIES

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### ABSTRACT

*Microencapsulation is the latest technology widely used where various photochemical and functional components are being encapsulated under the coating material preventing it to expose in outside atmosphere and also it releases its contents at the target site resulting in overall increase in bioavailability. Moreover, the technique has provided ease to preserve the core material intact and does not allow any interaction with the shell material. The microcapsules may have variations in its size and shape depending upon type of material to be enclosed. This technique has come out with a boon for food industries as there are way lots of flavoring substances and essential oils in various food products. There are various technologies being discussed here for microencapsulation having their active participation in achieving the efficient bioavailability of phytochemicals as well as various essential components.*

**KEYWORDS:** Microencapsulation, Microcapsules & Phytochemicals

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### INTRODUCTION

Encapsulation is the technique by which, the core materials either solids, liquids or even gases are enclosed inside the thin layered coating material. The product obtained is called as **Microcapsules**. There are two components of microcapsules i.e., Core material and Shell material. **Core material** is defined as the specific material, to be coated. It can be in liquid or solid in nature. It should be non-reactive with coating material. Vitamins, volatiles, drug, phytochemicals, enzymes, antioxidants and lipids (like fish oils) may act as core material. **Shell material** is the inert substance, which coats on core material with desired thickness. It should be non-reactive with core material and atmosphere too. Inert materials, polymers, starches, alginates, cellulosic material, waxes, resins can be used as encapsulant material/wall material/coating material.

### MICROENCAPSULATION TECHNOLOGIES

This technology has been in use by the food industries for more than six decades. In a broad spectrum, it is used in food processing for the coating of various acidulants, essential oils, various flavors and also other ingredients like raisins and other confectionary products, which may be attained by microencapsulation and macro-coating techniques, respectively

### Co Acervation Method

This method is mainly used to encapsulate essential oil (core material) which is dispersed into cationic aqueous polymer or gelatin. Later, the gum Arabic or anionic polymer solution can be added to the previous dispersion as second polymer solution. When these two polymers form a complex, the shell material deposits onto

the core particles. This process can also be accelerated by adding salt or by dilution of medium or by altering pH or temperature. Finally, these microcapsules can be stabilized by desolvation, cross linking (with formaldehyde) or thermal treatment.

### **Spray Drying Method**

Spray-drying is one of the very common and oldest processes to encapsulate active agent. Spray-drying of active agent is commonly achieved by dissolving, emulsifying, or dispersing the active in an aqueous solution of carrier material, followed by atomization and spraying of the mixture into a hot chamber (Barbosa-Cánovas et al. 2005; Gharsallaoui et al. 2007). Spray-dryers in the food industry are usually atomizing the in feed with a high pressure nozzle or centrifugal wheel (also called rotary atomizer) and operate with a co-current flow of air and particles to give minimal overheating of the particle. The size of the atomizing droplets depends on the surface tension and viscosity of the liquid, pressure drop across the nozzle, and the velocity of the spray. The size of the atomizing droplets also determines the drying time and particle size.

### **Drop Gelation Method**

Microspheres that are made of gel-type polymers, such as alginate, are then produced by dissolving the polymer in an aqueous solution. The active ingredients in the mixture are then suspended. It is then allowed to extrude through a precision device, producing

### **Pan Coating Method**

In Pan Coating method, the material to be coated gets mixed with a dry coating material. At high temperature, the coating material melts and gets enclosed with the core particles, followed with solidification by cooling. The coating material can also be applied gradually to core particles by tumbling it in a vessel rather than using this previous method.

### **Spinning Disk Method**

The core particles are suspended in liquid shell material and then poured into a rotating disc. The disc then performs the spinning action and the core particles get coated. Once the shell material gets solidified, core particles from its centrifugal action casts from the edge of the disc. Spinning Disk Method is rapid, cost-effective, and has high production efficiencies.

### **Co Extrusion Method**

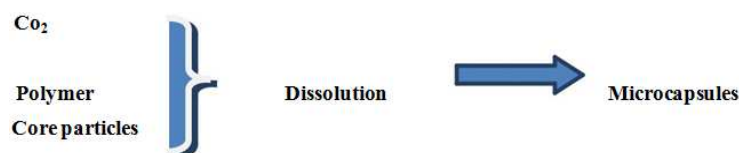
Core and shell materials are poured into concentric tubes and forms droplets, due to vibration. The shell material then gets hardened, by chemical cross linking or solvent evaporation or cooling. This process can be optimized, by using different types of extrusion nozzles.

### **Polymer Encapsulation by Rapid Expansion of Supercritical Fluids**

The fluid is said "supercritical", when it is heated above its critical temperature and compressed above its critical pressure. It is highly compressible gas that possess various properties of both liquids and gases. The most widely used supercritical gases are carbon dioxide (CO<sub>2</sub>) and nitrous oxide (N<sub>2</sub>O). A small variation in temperature or pressure leads to a large change in their density.

The shell material and the supercritical fluid (along with the active ingredient) are kept at high pressure and then

released through a small nozzle at atmospheric pressure. The sudden drop in pressure results in desolvation of the shell material, which is then gets deposited around the active ingredient (core) and forms a coating layer. Various core materials such as pigments, vitamins, flavors, pesticides and dyes can be encapsulated using this method. Paraffin wax and polyethylene glycol can be used as shell material for encapsulating core substances. The only demerit of this technique is that the shell material and the active ingredient must be fairly soluble in supercritical fluids.



### Solvent Evaporation Method

Solvent Evaporation Method is the most extensively used technique of microencapsulation. In this method, an aqueous solution of the active ingredient (may contain stabilizing agent) is prepared. It is then added to the polymer solution in solvents like dichloromethane or chloroform. It must be added with vigorous stirring resulting into primary water in oil emulsion. Then multiple emulsions (w/o/w) are formed by adding the primary emulsion into a large volume of water (containing an emulsifier like PVA or PVP). This double emulsion is then stirred continuously till the organic solvent evaporates and solid microspheres formation takes place. These microspheres can then be washed and dried.

### Polymer-Polymer Incompatibility (Phase Separation)

In this method, two polymers may be used which are soluble in a common solvent, but immiscible with one another. These polymers then form two distinct phases; one is rich in the polymer forming the capsule walls, the other in the incompatible polymer which induces the separation of the two phases. The second polymer is not included in the part of finished microcapsule.

### FURTHER DETAILS OVER TECHNOLOGIES

Technology	Process Steps	Morphology	Load (%)	Particle Size ( $\mu\text{m}$ )
Spray-Drying	1. Disperse or dissolve active in Aqueous coating solution			
	2. Atomize	Matrix	5-50	10-400
	3. Dehydrate			
Fluid Bed Coating	1. Fluidize active powder			
	2. Spray coating	Reservoir	5-50	5-5000
	3. Dehydrate or cool			
Emulsification	1. Dissolve active and emulsifiers in Water or oil phase.			
	2. Mix oil and water phases under Shear	Matrix	1-100	0.2-5000
Drop Gelation	1. Dissolve or disperse active in alginate solution	Matrix	20-50	200-5,000
	2. Drop into gelling bath			
Freeze or Vacuum Drying	1. Dissolve or disperse active agent and carrier material in water			
	2. Freeze the sample	Matrix	Various	20-5,000
	3. Drying under low pressure			
	4. Grinding (option)			

## TARGET ACTION OF ENCAPSULATION TECHNIQUE

It exhibits target drug delivery system approach.

- Controlled release of food ingredients at the right place and the right time is a key function of microencapsulation.
- It helps in protecting the sensitive food components as well as masks the flavor components thereby preventing nutritional loss.
- Retarding evaporation of a volatile core.
- Improving the handling properties of a sticky material.
- It prevents oxidation of certain vitamins.

## MOTIVE BEHIND THE INTEREST OF FOOD INDUSTRIES TO APPLY MICROENCAPSULATION TECHNIQUE

- Encapsulation is equals to entrapment which can protect the core material from outside environment (e.g., heat, moisture, air, and light). It prevents degradation.
- The transfer rate of the core material to the outside environment is negligible.
- The core material packaging can be modified and made easier to handle.
- The control and target release of the core material increases its bioavailability.
- The flavor of the core material can be masked and used directly at the mode of action.
- This technique can be used to separate components within a mixture so as it will not react with one another.

## BENEFITS OF ENCAPSULATION

The possible benefits of microencapsulated ingredients in the food industry could be

- Superior handling of the active agent (e.g., conversion of liquid active agent into a powder, which might be dust free, free flowing, and might have a more neutral smell).
- Immobility of active agent in food processing systems.
- Improved stability in final product and during processing (i.e., less evaporation of volatile active agent and/or no degradation or reaction with other components in the food product such as oxygen or water).
- Improved safety (e.g., reduced flammability of volatiles like aroma, no concentrated volatile oil handling).
- Creation of visible and textural effects (visual cues).
- Adjustable properties of active components (particle size, structure, oil- or water-soluble, color).
- Off-taste masking.
- Controlled release (differentiation, release by the right stimulus).

## APPLICATIONS OF ENCAPSULATION TECHNIQUE

### **Savitha Krishnan, Rajesh Bhosale, Rekha S. Singhal\*, “Microencapsulation of Cardamom Oleoresin: Evaluation of Blends of Gum Arabic, Maltodextrin and a Modified Starch as Wall Materials”**

The spice oleoresins provide complete flavor profile than their respective essential oils, but their sensitivity is too high towards light, heat and oxygen. The present work reports, on the microencapsulation of cardamom oleoresin, by spray drying, using binary and ternary blends of gum Arabic, maltodextrin, and modified starch as wall materials.

### **Glauciaaguilarrochaa\*, Carmen Sílvia Fávaro-Trindadeb<sup>1</sup>, Carlos Raimundo Ferreira Grossoa<sup>2</sup>, “Microencapsulation of Lycopene by Spray Drying: Characterization, Stability and Application of Microcapsules”**

Lycopene is the most vital phytochemical present in tomato (*Lycopersiconesculentum*) having medicinal effect, for cancer treatment. The instability of lycopene is a major issue. Microencapsulation is the best technique, to prevent instability. The study was conducted to microencapsulate lycopene by spray drying, using a modified starch (Capsule®) as an encapsulating agent, and to assess the functionality of the capsules. Likewise, the microcapsule consists of a layer of encapsulating material that acts like a protective film, isolating the active substance and avoiding the effects of its improper exposure (Jizomoto et al., 1993; Ré, 2006).

### **Charikleia Chramioti and Constantinatzia, “Encapsulation of Fennel Essential Oil Using Freeze Drying Method: Evaluation of Process and Quality Characteristics of the Encapsulated Products”**

Fennel essential oil is a flavor which is available in powder as well as oleoresin form. The freeze drying method is mainly applied in flavor encapsulation. Fennel is having good antioxidant as well as antifungal activity so it is selected for this method. The main aim of this study was to evaluate the encapsulation of fennel oil in modified starch, maltodextrin 21DE and chitosan. Fennel based encapsulated products are successfully produced by these techniques and, the chitosan is proved to be more efficient among all methods.

### **Markus et al Found Encapsulation as the Effective Technique for Pesticide Formulation.**

Pesticide formulation is the advanced technique to be used by encapsulation for the controlled release of pesticides in agriculture. This technique helps in reducing the wastage of pesticide which was supposed to take place during spraying of pesticides on crops.

## EFFECTS OF ENCAPSULATION ON PARAMETERS OF FOOD PRODUCTS

- Hargreaves 2006 mentioned in his article that there is no significant change in overall sensory attributes.
- Moreover it improves nutritional content and to add other bioactive ingredients with known healthy benefits.
- The textural property of encapsulated ingredients remains unaltered as it is of inert nature.

## FUTURE ADVANCEMENTS IN ENCAPSULATION TECHNIQUE ENSURING STABILITY

- Champagne & Fustier 2007 suggests the opportunities for use of microencapsulation in the food to develop the capsules having capacity to control the release and delivery of the core material at a specific time during digestion and at a specified site in the body.
- Krasaekoopt et al. 2003; Anal & Singh 2007 investigated that the technique most widely applied for encapsulation

of probiotics involves the use of polysaccharides to form gelled particles.

- Sunley 1998; Pszczola 2005 suggests that New developments in a range of microencapsulation technologies continue to address different functionality challenges that occur when formulating bioactive ingredients into functional foods

## CONCLUSIONS

The microencapsulation technique offers a variety of opportunities such as Protection, Masking flavonoids, target drug delivery, facilitation of handling etc. which is widely accepted as per commercial level. The most common technique used for the encapsulation of active phytochemicals is the spray drying method, resulting into its higher efficiency and stability.

Tiny encapsulated droplets exhibits target delivery without reacting with atmospheric conditions due to its non-reactive wall material. The studied microcapsules presented good functionality and good potential for use in foods since they were able to release the lycopene during preparation of the studied system and to color it homogenously.

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