MICROENCAPSULATION OF FOOD FLAVORS

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ABSTRACT: -

Flavors are often among the foremost valuable ingredients in any food formula. Development of latest functional foods requires technologies for incorporating health promoting ingredients into food. One must remember that the functionality or bioavailability of the incorporated food must not reduce. The flavor industry is active in developing new encapsulation techniques that provide flavor release under specific conditions, adding valuable flavor impact. Microencapsulation technology allows a compound to be encapsulated inside any tiny sphere known as microsphere or microcapsule. Encapsulation describes different processes to hide a lively compound within a protective wall material and it is often applied to treat flavors so to impart a point of protection against evaporation, reaction or migration during a food. Encapsulation of flavors has been attempted and commercialized using different methods. This review gives detail information about the methods and the general aspects of microencapsulation of flavors and its applications. Recent developments in each of these techniques are discussed in this review. A timely and targeted release improves this technique. Microencapsulation is no more just an added-value technique, but the source of totally new ingredients with matchless properties.

INTRODUCTION: -

Microencapsulation is expanding on an enormous rate which is actually a unique way by which very tiny droplets or particles of liquid are surrounded by a coating or embedded in a homogenous or heterogeneous matrix, yielding capsules ranging from less than one micron to several hundred microns in size. This technology has been well developed and accepted within the pharmaceutical, chemical, food and many other industries.

Microencapsulation also provide a key functionality which is; controlled release of food ingredients or flavours at the right place and the right time.

Microencapsulation can provide a physical barrier between the core compound and the other compounds of the product. The core could also be composed of only one or several ingredients and therefore the wall could also be single or double layered. Microencapsulation has many applications in food industry like to guard , isolate or control the discharge of the given substance which is of growing interest.

This review article contains information about microencapsulation of food flavours. As flavours are the most valuable ingredient in any food formula, because they are volatile and delicate; preserving the flavours is the top concern of food manufactures.

Microcapsule system:

The microcapsules contain core material which is being protected and locked up in the membrane that isolates it from external medium. The core material may be composed of just one or several types of ingredients and carrier may be single or multi-layered. A limited number of microencapsulating techniques exist but an enormous range of different materials can be used; including proteins, carbohydrates, gums, lipids and cellulose. The choice of wall material is decided accordingly and also upon the number of factors including; the process of encapsulation, expected product requirements or objectives, economics and many more.

For encapsulation of the flavour compounds, the carrier material shouldn't react with the core material; should be in a form which can be easily handled; giving the maximum protection to the active ingredient against the external factors; must ensure good emulsion-stabilization properties and effective redispersion behaviour to release the flavour at the time and place desired.

It's also interesting to know that how this technique of microencapsulation is being developing around the world and the way it is growing. The food encapsulation market is majorly driven by the rising demand for encapsulated flavours fromfood manufacturers and increasing demand for fortified food products. It's been used worldwide and has many of the advantages which are being discussed in this review article.

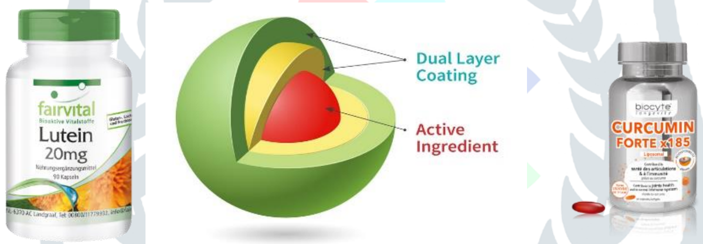

Table 1. applications of different capsulation method in food industry

Encapsulation technique	Encapsulated form	Application area
Coacervation	Paste/powder/capsule	Chewing gum, toothpaste, baked foods
Spray drying	Powder	Confectionery, milk powder, instant desserts, food flavours, instant beverages.
Fluid bed drying	Powder/granule	Prepared dishes, confectionery
Spray cooling/chilling	Powder	Prepared dishes, ices
Extrusion	Powder/granule	Instant beverages, confectionery, teas

Encapsulation technique	Encapsulated form	Application area
Molecular inclusion	Powder	Confectionery, instant drinks, extruded snack

RECENT DEVELOPMENTS IN MICROENCAPSULATION:

The food encapsulation market is estimated to be valued at USD 9.9 billion in 2020 and is projected to grow at a CAGR of 7.5% recording a value of USD 14.1 billion by 2025. There is an increasing demand for encapsulated flavours from convenience food manufacturers and increasing demand for fortified food products. However, the high cost is the only restraining factor for this market. As per industry experts, the price of any ingredient rises by over 50% when subjected to encapsulation procedures. Also, the capital investment involved in machinery and material cost is added to the final product.

- **The market for probiotics is projected to record the highest CAGR during the forecast period.**

Probiotics helps in maintaining vigorous levels of friendly microorganism in human intestine and helps in preventing infection, slowing down the growth of harmful bacteria, avoiding reduction of immunity, prevention of imbalance in digestive system. Probiotics are extensively used in the functional food segment. These probiotics are encapsulated to protect them from being exposed externally.

- **The functional food segment is estimated to account for the largest market share in 2020, in terms of application.**

According to industry experts, across the world the adoption rate of food encapsulation has been as high as 40% within the functional food segment for its ingredients. Therefore the segment is estimated to dominate within the market in 2020 for food encapsulation, supported application, and is closely followed by dietary supplements; which is that the next major application of these ingredients.

- **Asia Pacific to grow at the highest CAGR in the food encapsulation market between 2020 and 2025**

The North American region dominated the market in 2018, and therefore the Asia Pacific region is projected to be the fastest- growing market during the forecast period within the food encapsulation market. Factors driving the Asia Pacific market growth include the increasing adoption of technological advancements within the region, growing income, and growing demand for functional food and dietary supplements among the urban population.

- **In terms of method of encapsulation, ingredients encapsulated through a physical method accounted for the major market share.**

Food encapsulation demand is targeted by a couple of ingredient manufacturing companies, like functional food ingredients, flavors, and colours. With the utilisation of advanced technology, the worth of the ingredient rises, and hence, the manufacturers prefer low cost-efficient encapsulation methods. Thus, the physical methods are the foremost demanded method used for encapsulation of food ingredients.

- **The market for dietary supplements is projected to record the highest CAGR during the forecast period.**

The demand for dietary supplements is on the rise in developed and developing countries among the millennial population. Vitamins, enzymes, and minerals are a number of the main constituents of dietary supplements, which require targeted delivery. Also, industry experts foresee the adoption rate for dietary supplements to rise the highest in the coming five years.

- **Polysaccharides are the most preferred shell phase for food encapsulation.**

The polysaccharides segment accounted for the most important marketplace for shell material in 2018 and is projected to follow an equivalent trend through 2025. Polysaccharides are a composition of repeating monosaccharide units connected by glycoside bonds. Polysaccharides are easily chemically modifiable and provide numerous textures and viscosities. Owing to their enormous molecular structure and skill to entrap bio-actives, polysaccharides are considered the most-suitable building blocks for the systems of delivery.

Recent Developments: -

- In July 2019, DSM (Netherlands) entered into a joint venture with Evonik (Germany) to produce encapsulated omega-3 fatty acids, reducing the pressure on fish stocks, and supporting the aquaculture industry.
- In May 2017, Lycored (Israel) entered into a joint venture with a biotechnology company, Algatechnologies (Israel), to distribute Algatech's AstaPure in the form of beadlets, which will help in increasing the brand's commercial reach for this product range in the North American market.
- In January 2017, DSM (Netherlands) launched a new product, MEG-3, with new encapsulation technology.

MICROENCAPSULATION TECHNIQUES: -

Encapsulation of food ingredients into coating materials are often achieved by several methods. The selection of the process is governed by the physical and chemical properties of core and coating materials. Many microencapsulation processes exist but are usually categorized into two groupings: chemical processes and mechanical or physical processes.

MECHANICAL OR PHYSICAL METHODS:

SPRAY DRYING

Spray drying may be a mechanical microencapsulation method developed within the 1930s. An emulsion is ready by dispersing the core material, usually an oil or active ingredient immiscible with water; into a concentrated solution of wall material until the specified size of oil droplets are attained. The resultant emulsion is atomized into a sprig of droplets by pumping the slurry through a rotating disc into the heated compartment of a spray drier. There the water portion of the emulsion is evaporated, yielding dried capsules of variable shape containing scattered drops of core material collection of capsules is done through continuous discharge from the spray drying chamber. This method also can be wont to dry small microencapsulated materials from aqueous slurry that are produced by chemical methods.

PAN COATING

In pan coating, solid particles are mixed with a dry coating material and therefore the temperature is raised in order that the coating material melts and encloses the core particles, and then is solidified by cooling; or, the coating material are often gradually applied to core particles tumbling during a vessel instead of being wholly mixed with the core particles from the start of encapsulation.

CENTRIFUGAL EXTRUSION PROCESS

Centrifugal extrusion processes generally produce capsules of a larger size, from 250 microns up to a few millimetres in diameter. The core and therefore the shell materials, which should be immiscible with each other are pushed through a spinning two-fluid nozzle. This movement results into an unbroken rope which naturally splits into round droplets.

SUSPENDED NOZZLES

A number of workers have produced microcapsules by ejecting droplets that contain a core and shell material from suspended nozzles into a gas phase, which is usually air. The droplets undergo a gas phase until the capsule shell is solidified by cooling, or they fall under a curing bath where they're gelled and subsequently harvested.

CHEMICAL METHODS:

INTERFACIAL POLYCONDENSATION

In interfacial polycondensation, the 2 reactants during a polycondensation meet at an interface and react rapidly. This include the classical Schotten-Baumann reaction which is between an acid chloride and a compound containing an active atom , like an amine or alcohol, polyesters, polyurea, polyurethane. Under the proper conditions, thin flexible walls form rapidly at the interface. A solution of the pesticide and a diacid chloride are emulsified in water and a solution containing an amine and a polyfunctional isocyanate is added. Base is present to neutralize the acid formed during the reaction. Condensed polymer walls form at the interface of the emulsion droplets instantaneously.

INTERFACIAL CROSSLINKING

Interfacial cross-linking springs from interfacial polycondensation, and was developed to avoid the utilization of toxic diamines, for pharmaceutical or cosmetic applications. In this method, the tiny bifunctional monomer containing active hydrogen atoms is replaced by a bio sourced polymer, sort of a protein. When the reaction is performed at the interface of an emulsion, the acid chloride reacts with the varied functional groups of the protein, resulting in the formation of a membrane. The method is extremely versatile, and therefore the properties of the microcapsules (size, porosity, degradability, mechanical resistance) are often customized. Flow of artificial microcapsules in microfluidic channels.

IN SITU POLYMERISATION

In a few microencapsulation processes, the direct polymerization of one monomer is administered on the particle surface. In one process, e.g. cellulose fibres are encapsulated in polyethylene while immersed in dry toluene. Usual deposition rates are about 0.5µm/min. Coating thickness ranges 0.2–75 µm (0.0079–2.9528 mils). The coating is uniform, even over sharp projections. Protein microcapsules are biocompatible and biodegradable, therefore the presence of the protein backbone renders the membrane more resistant and elastic than those which are obtained by interfacial polycondensation.

MATRIX POLYMERISATION

In a number of processes, a core material is imbedded during a polymeric matrix during formation of the particles. A simple method of this sort is spray-drying, during which the particle is made by evaporation of the solvent from the matrix material. However, the solidification of the matrix can also be caused by a chemical process .

PHYSICOCHEMICAL METHODS:

IONOTROPIC GELATION

Ionotropic gelation occurs when units of acid within the chains of the polymer alginate, crosslink with multivalent cations. These may include, calcium, zinc, iron and aluminium.

COACERVATION – PHASE SEPARATION

Coacervation-phase separation consists of three steps administered under continuous agitation.
1. Formation of three immiscible chemical phases: liquid manufacturing vehicle phase, core material phase and coating material phase.
2. Deposition of coating: core material is dispersed within the coating polymer solution. Coating polymer material coated around core. Deposition of liquid polymer coating around core by polymer adsorbed at the interface formed between core material and vehicle phase.
3. Rigidization of coating: coating material is immiscible in vehicle phase and is made rigid. This is often done by thermal, cross-linking, or dissolution techniques.

ADVANTAGES OF MICROENCAPSULATION:

- **Flavour and odour masking:** Minimise unpleasant tastes and odours and increase consumer acceptance.
- **Release parameters:** Release mechanism is engineered in such how that the core substance is timed to release at a specific temperature or in stomach for digestion.
- **Protection:** Encapsulation allows the protection from acids, moisture, heat, and exposer to oxygen. Moreover, the nutrient is often shielded from processing losses.
- **Precision:** Thesteadiness afforded by encapsulated ingredients allows measuring and delivery of precise levels of desired nutrient.
- **Minimise overages:** Tomake sure a label claim is met, often overages [higher levels] must be added to catch up on expected losses in nutrient potency; occur during processing. The high costs of the many vitamins, these overages can eat up the margin of profit over time. Nutrient inside the capsule is protected in such how, that it reduces losses and reduce overages leading to significant savings of cost.
- **Ease of handling:** Ingredients are contained inside a capsule, and are dry and free- flowing therefore easy to handle.

Controlled flavour release: -

Controlled release may be defined as a method by which one or more active agents or ingredients are made available at a desired site and time and at a specific rate. Many researchers have sought a better understanding of the effects that govern the flavour release from complex matrices as this represents an important target in many fields, including the food industries. For matrix systems to capsulate volatile compounds, release depends on several mutually dependent processes like diffusion of the volatile compound through the matrix, type and geometry of the particle, transfer from the matrix to the environment, and degradation/dissolution of the matrix material.

De Roosin 2020 showed that two factors control the speed of flavour release from products, the comparative volatility of the aroma compounds within the food matrix and air phases under equilibrium conditions (thermodynamic factor) and the resistance to mass transport from product to air (kinetic factor). The mechanism of release for the capsule could also support solvent effects, like melting, diffusion, degradation, or particle fracture.

Release of flavour by diffusion

Diffusion is controlled by the solubility of a compound in the matrix (this establishes a concentration in the matrix which drives division) and the permeability of the compound through the matrix. Diffusion is important in food because it is the dominant mechanism in controlled release from encapsulation matrices. It should be obvious that if the food component is not soluble in the matrix, then it will not enter the matrix and so diffusion will not take place irrespective of the pore size of the matrix.

Release of flavour by degradation

The release of lively compound from a matrix- type delivery system could also be controlled by diffusion, erosion or a mixture of both. Homogeneous and heterogeneous erosion are both detectable. Heterogeneous erosion occurs when degradation is confined to a thin layer at the surface of the delivery system, whereas homogenous erosion is a result of degradation occurring at a uniform rate throughout the polymer matrix

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Release of flavour by swelling

In systems controlled by swelling the flavour dissolved or dispersed in a polymeric matrix is unable to diffuse to any significant extent within the matrix. When the matrix polymer is placed inside a thermodynamically compatible medium, the polymer swells dueto absorption of fluid from the medium. The aroma within the swollen part of the matrix diffuses out then. The degree of swelling is controlled by water absorption or presence of solvents such as glycerine or propylene glycerol.

Release of flavour by melting

This mechanism of release involves the melting of the capsule wall to release the active material. This is readily accomplished in the food industry as there are numerous materials that can be melted and that are approved for food use (lipids, modified lipids or waxes). In such applications, the coated particles are stored at temperatures which are below the melting point of the coating and then heated above this temperature during cooking or preparation.

CONCLUSION: -

The stakes in the functional food and pharmaceutical industry is the efficient encapsulation of high added value ingredients, such as polyunsaturated fatty acids, flavours, vitamins and ingredients, the volatile permeability of which is used to improve functionality.Although all the techniques discussed have some advantages over the other techniques even then categorical the most appropriate technologies are adopted commercially like spray drying to the fullest. The choice of an appropriate technique of encapsulation depends on the properties of the flavour compounds, the degree of stability required during storage and processing, the properties of the food components, the precise release properties required, the utmost obtainable flavour load within the powder and therefore the cost. In addition, fluid- bed process is additionally becoming a promising encapsulation technique for large- scale production of flavour powders to be applied in food industry. Today, the comprehensive technology of encapsulation enables it to satisfy all relevant product requirements, including tailoring food properties, easy product handling, improved shelf- life and controlled release. There is ample scope of using two or three different techniques in complementation to each other as per the requirement and convenience and a lot of work needs to be done on different combinations of newly developed and traditional wall matrix materials.

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