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RESEARCH ARTICLE

Microencapsulation in Food Science and Biotechnology in Iraq

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Abstract

Microencapsulation is defined as a packaging technology for solid, liquid or gaseous materials. Sealed microcapsules can release their contents at controlled speeds under specific conditions, and can protect the encapsulated product from light and oxygen. The microencapsulation consists of microparticles formed by a porous polymeric membrane containing an active substance. The material or mixtures of materials to be encapsulated can be covered or trapped within another material or system. A microcapsule consists of a semi-permeable, spherical, thin and strong membrane around a solid / liquid center. The materials used for encapsulation can be gelatin, fats, oils, gum arabic, calcium alginate, waxes, wheat starch, corn, rice, potatoes, nylon, cyclodextrin, maltodextrin, sodium caseinate, whey protein or protein of soy. The applications of microencapsulation are directed to the industry, it is given to the textile, metallurgical, chemical, food, cosmetics, pharmaceutical and medical industries. Among the techniques used to microencapsulate are spray drying, cooling drying, freeze drying, coacervation and extrusion. The substances that are microencapsulated can be vitamins, minerals, dyes, prebiotics, probiotics, nutraceutical flavors, antioxidants, odors, oils, enzymes, bacteria, perfumes, drugs and even fertilizers.

Key words: *Encapsulation techniques in food, Encapsulation theory.*

Introduction

The objective of this work was to review the importance of microencapsulation in food, explain the encapsulating agents used as polysaccharides, which include starch, maltodextrin, corn syrup, gum arabic, agar, fibers and carbomethylcellulose; lipids such as stearic acid, mono and diglycerides and lecithins and proteins such as gelatin, casein, whey, soy, wheat; and detail the principal methods used to encapsulate: liposomes, coacervation, co-crystallization, spray drying, extrusion, emulsion, spray chilling or freezing and inclusion complex [1].

Encapsulation can be defined as a technique by which solid or gaseous liquid droplets; particles are coated with a porous polymer film containing an active substance [2], this membrane, barrier or film it is generally made of components chains to create a network with hydrophobic and/or hydrophilic properties [3]. The term microencapsulation is similarly used in the food industry, when low molecular weight substances are encapsulated or in small quantities, although the two terms, encapsulation and microencapsulation, are used interchangeably [4]. Among the first practical applications of microencapsulation pharmaceutical, medical, textile, food stands [5,6], pesticide [7, 8], cosmetics, chemistry [2], printing [9] agrochemicals (Villamizar and Martínez) fragrances, dyes, biomedical antimicrobial agents [10-12]and plastics [13].Regarding the food area, the applications of this technique have been increasing due to the protection of encapsulated materials from factors such as heat and humidity, allowing to maintain its stability and viability.

The microcapsules help the food materials used to resist the conditions of processing and packaging improving taste, aroma, stability, nutritional value and appearance of their products [14]. An especially important application in food is nanoencapsulation that involves the incorporation, absorption or dispersion of bioactive components in small vesicles with nano (or submicron) diameter [15], these nanoparticles encapsulated at the interface of emulsion drops they can improve stability and control drops [16]; and be used as edible transporters for flavor-aroma components or for encapsulation or nutraceuticals, as well as to improve the elasticity of plastics and bioactive food packages [17].The structure formed by the microencapsulating agent around the microencapsulated substance (nucleus) is called a wall, this protects the nucleus against deterioration and release under desired conditions [18].

The microencapsulation technique has allowed to solve some problems by limiting the applications of ingredients and food additives, since it can control the elimination of flavorings, as well as reduce volatility, hygroscopicity and reactivity by increasing the stability of products under adverse environmental conditions [19]. The encapsulation processes can be divided into two: chemical processes and mechanical processes.

The chemical processes are divided into the techniques of coacervation, co-crystallization, interfacial polymerization, ionic gelation, polymer incompatibility, liposome entrapment and molecular inclusion; mechanical processes include spray drying, freeze / cool and extrusion drying [20].Substances that are encapsulated. The encapsulation processes were developed between 1930 and 1940 by the National Cash Register for the commercial application of a dye from gelatin as an encapsulating agent [20]; its beginning in microencapsulation products began in 1950 in the investigations within the pressure-sensitive cover for the production of copy paper [19]. Nowadays many substances can be encapsulated in solid powdered particles or they can be microencapsulated in structured emulsions [21].

Below are some of them: perfumes, fertilizers, precursors in print [19], lemon oil, drugs, lipids, volatile flavors [23], tissue conservation [24], probiotics [25], prebiotics, nutraceuticals [26], fruit seeds such as banana, grapes, guava, papaya, apple, blackberry, granadilla and citrus seeds have also been encapsulated among other substances [25]. In this regard, encapsulation offers great scope for the conservation, germination and exchange of several fruit species, resulting in a promising technique for the conservation, transport of transgenic plants and non-seed producing plants [25], lactase [27], dyes, enzymes, phytosterols, lutein, fatty acids, plant pigments, antioxidants, components of aromas and oleoresins, vitamins, minerals [28].The microencapsulation of essential oils is an interesting technology used in the food industry, preventing its volatilization and extending the life of these biological components [29].

Two experiments of emulsification, composition and homogenization conditions were optimized for the preparation of a food emulsion to be spray dried. The average oil droplet size may be influenced by the composition of the emulsion and the homogenization pressure, but not by the number of phases. With an average oil droplet size below 2 mm and a maximum viscosity of 179 mPa, appropriate emulsions could be produced with 50% oil and 2.2% beet sugar.

Physical-chemical parameters such as particle morphology, particle size and generally removable fat, reflect good efficiency in microencapsulation and indicate good oxidative stability [30].Another example of encapsulation is Omega-3 [31, 32]. Microencapsulation has been successfully used to improve the survival of microorganisms in dairy products by protecting sensitive components in food and some environmental factors, for example heat, oxygen and humidity [29] insuring them against nutritional loss and incorporating mechanisms within the formulation. An example of the above is cheese powder, which can be used in sauces, dressing, biscuits, chips and directly as a flavoring in hot dishes such as spaghetti and soups; However, in production a certain amount of aromas during drying is inevitable [33].

Matured cheeses require prolonged ripening to develop characteristics such as desirable taste, texture and aroma; However, several methods such as raising the ripening temperature, using modified starter microorganisms, adding attached cultures and exogenous enzymes, can be used to accelerate ripening. The direct addition of enzymes to milk during cheese making is undesirable due to the loss of enzymes in the whey, poor distribution, reduced yield and poor cheese quality.

To solve the above problems, the direct addition of encapsulated enzymes can solve them, this is because the enzyme immobilized in microcapsules is physically separated from the milk substrate and the curd mixture, this allows the enzyme to make cheese it is released into the product matrix by degrading the capsule during maturation. An example of encapsulated flavor highlighting enzymes is: chymosin, proteinases and lipases in liposomes, carrageenans and milk fat.

The viability of Bifidobacterium bifidum and Lactobacillus acidophilus by any extrusion or emulsion technique has been successfully monitored in cheeses, by keeping the number of probiotic bacteria alive. Experimentally, cheeses containing microencapsulated probiotics have not had differences with the control cheese, in terms of sensory properties. It has been shown that Lactobacillus ramnosus colonies microencapsulated in an alginate matrix have maintained their viability above 48 h at pH 2; otherwise it occurred when free cells (without encapsulation) were completely inactivated under these same conditions [34].

Another example related to dairy products is yogurt, in which bifidobacteria are microencapsulated to increase the viability in this fermented beverage ; in the case of spray dried yogurt after 6 weeks of storage at 4 and 21 ° C. This is because microencapsulation reduces cell damage by retaining cells within encapsulating materials.

The microencapsulation of Bifidobacterium lactis has shown significantly high survival rates in the presence of stimulated gastric juices and considerably higher viability, during the shelf life compared to free cells. Also the whey, liquid product obtained during cheese making can be spray dried for the production of whey powder and / or whey protein concentrates [35]. Recently, a great interest in natural pigments has arisen mainly due to the demand for healthy food products and opportunities for innovation in the sector.

The use of these pigments requires chemical knowledge of their molecules and their stability, in addition to adapt to the conditions of use during processing, packaging and distribution. The industry requires technologies that protect natural pigments from the environment, due to their instability in the presence of light, air, humidity and high temperatures. Currently, an alternative is microencapsulation technology [36]. Carotenoids are used as colorants in food, beverages, cosmetics and animal feed, mainly poultry and fish. During processing and storage, carotenoids can easily be rearranged into different geometric isomers and oxidized, this results in the decrease or loss of the dye and its biological properties.

The main application alternatives to increase the stability of carotenoids and thus allow their incorporation in hydrophilic environments, is the microencapsulation technique through the spray drying method called spray drying. To encapsulate the lycopene by spray drying or spraying, 60 g of gum arabic are taken, and sucrose, solubilized in 200 mL of water at 45 ° C while stirring until it reaches a temperature of 30 ° C. The microcapsules are prepared by dissolving lycopene crystals (15 mg) in 20 mL of dichloromethane, which are added to the polysaccharide solution and vigorously homogenized at 7000 rpm for 30 min at room temperature. Distilled water (80 mL) is added until a solution of soluble solids of 20% (w / v) is reached and maintained under stirring conditions during the process.

The spray dryer is operated at an air flow rate of 30 mL / min, inlet and outlet of air temperatures of 170 and 113 ° C respectively and air pressure of 5 kgf / cm2. The microcapsules are immediately stored, under N2 in glass bottles at -20 ° C. Lycopene crystals are made from fresh tomatoes (Lycopersicum esculentum), the methodology for the elaboration of these crystals consists of 4 steps: prior elimination of water during 30 min of extraction and 30 mL of commercial ethanol.

The second step 120 min extraction with ethyl acetate. The third step is complete evaporation of the solvent in a broken evaporator and the last stage is crystallization. Recent interest in the potential use of rose flower pigments (Rosa rugosa Thunb) has drawn attention to develop methods for the extraction and encapsulation of these pigments [37].The method of microencapsulation of the Uruguayan pigment (Bixa orellana) can be carried out using as a chitosan encapsulating agent using 50 mg solutions of the urucu pigment (Bixa orellana) and 3 g of chitosan; To the above mixture, 5% acetic acid, 5% lactic acid and 5% citric acid are added, then homogenized and spray dried, at an air inlet temperature 180°C and air outlet temperature of 100°C.

The morphology, porosity and average size is analyzed with a scanning electron microscope; For the color grading a Lab Hunter system is used, it consists of a rectangular coordinate system for the definition of color in terms of luminosity (L *), red versus green and yellow versus blue (b *) [25]. Pigments such as lutein-enocyanin are encapsulated by spray drying, the methodology to encapsulate lutein and enocyanin is to solubilize in distilled water with magnetic stirring; Lutein dissolved in distilled water is also added with constant stirring, 0.1N NaOH is added until pH 10, maltodextrin (10%) and soy protein isolate (2%), homogenized through stirring to subsequently pass through drying aspersion.

The inlet temperature can be 117 °C and outlet temperature 75 ° C, an air flow of 600 L / h, with a feed rate of 5 mL / min and an atomization pressure of 20 psi [24].Prickly pear cactus pigments (Opuntia spp) can be encapsulated with maltodextrin or inulin, the methodology is described below: 30 g of cactus pigment are mixed with 15 g of ethanol and maltodextrin (6-30%) or inulin (3-15 %) with constant agitation; Maltodextrin previously swells in distilled water for 12 h.

In the case of inulin, it could be heated to 60 ° C, prior to the addition of the pulp or extract; The mixture is homogenized and subjected to spray drying operated at an inlet temperature ranging from 140-160 ° C to 120-160 ° C for maltodextrin and inulin respectively. The air flow, feed rate and atomization pressure were 60 L / h, 10 mL / min and 20 psi, respectively, for both encapsulating agents.

In the end, a powder is obtained that is stored in vials or jars of clean glass and excluded from light [16]. Astaxanthin, is one of several carotenoid xanthophilic pigments found in aquatic animals such as shrimp, crab, salmon and some other organisms. The usefulness of astaxanthin is as a source of pigmentation in the aquaculture industry; Recently, the application of this pigment has been as a nutraceutical and medicinal ingredient for the prevention and treatment of various diseases such as cancer, inflammations, infections caused by Helicobacter pylori and cardiovascular oxidative stress. Research has shown that astaxanthin is significantly more effective than carotene and lutein in preventing the photo-oxidation of ultraviolet light from lipids, having between 10 and 100 times more antioxidant activity than vitamin E and carotene respectively.

This pigment has been encapsulated in ethyl cellulose nanospheres, PCPLC (Poly (ethylene oxide) -4-methoxycinnamolatolchitosan), PB4 poly (ethylene oxide) -4- methoxyimimem, finding that PCPLC has had good encapsulation characteristics with an efficiency of 98%, while with ethyl cellulose the yield was poor; With PCPLC, astaxanthin showed minimal heat degradation in contrast to the unencapsulated pigment which was completely destroyed [11-14].

Anthocyanins are highly colored substances found in plants; They are used in food, nutraceutical and pharmaceutical preparations because they have mainly the colors red, violet and blue. Factors that affect the color and stability of anthocyanins include structure and concentration, pH, temperature, light, presence of co-pigments, enzymes, oxygen, ascorbic acid, sugar and their degradation products, proteins and sulfur dioxide. Microencapsulation when using spray drying is an economical method for the preservation of natural dyes [3].The microencapsulation of Bifidobacterium lactis can be carried out using gelana (0.1 g) and xanthan (0.2 g) with 20 mL of distilled water.

The above solution is mixed using magnetic stirrer and heated at 80 ° C for 1 h. The gel mixture is autoclaved at 121 ° C for 15 min. The cells are collected by centrifugation at 8000 g for 10 min at 4 ° C and the sedimented cell material is washed three times by re-suspension in 20 mL aliquots of sterile distilled water, followed by centrifugation. Finally, the cells are suspended in sterile distilled water to obtain a volume of 2.5 mL. One mL of this concentrate is mixed in 20 mL of xanthan gum and gel at 55 ° C, being able to estimate the size of the microcapsule containing bacteria, by laser diffractometry [22].

Probiotic bacteria can also be encapsulated using a calcium alginate polymer containing corn starch as a filler material, subsequently aseptic capsules are prepared using an emulsion method to produce capsules. The standard conditions used for encapsulation were 18 g / L alginate, bacterial culture (approximately 107 CFU / mL), 10 g / L cornstarch, the components are mixed and for 30 min it is compacted in 0.1 mol / L of calcium chloride solution, to subsequently release the bacteria using 0.1 m / L phosphate buffer [7].

This release of active probiotic cells in microencapsulated form has received attention during the last 10 years; this reduces loss of sensitive bacteria induced by external detrimental factors such as oxidative or acid stress during storage and digestion [19]. In this regard, it has also been found that encapsulation of Bifidobacterium pseudolongum with cellulose talato-acetate has increased the survival of bacteria under simulated gastric acid conditions, compared to non-encapsulated bacteria [30].

Lactobacillus acidophilus has been encapsulated in a mixture of alginate-inulin-xanthan gum managing to grow in carrot juice and survive 8 weeks of storage at 4 ° C with exposure to gastrointestinal conditions. This technique has protected Lactobacillus acidophilus by subjecting it to these conditions of time and storage, obtaining minor changes in viability. Minerals such as iron can be encapsulated in lecithin liposomes, an example can be milk with encapsulated iron sulfate [35].

The Main Advantages of Microencapsulation are:

- Protect the active material from degradation caused by the environment (heat, air, light, humidity), etc.
- The encapsulated compound is gradually released from the compound that has encompassed or trapped it at a certain point.
- The physical characteristics of the original material can be modified and make handling easier (a liquid material converted to dust), hygroscopy can be reduced, the density is modified and the material contained can be distributed more evenly in a sample.
- The taste and smell of the material can be masked.
- It can be used to separate components, so that they do not react.
- Stabilization of unstable active ingredients.
- Transformation of liquids into solids [38].

Agents used for Microencapsulation

Polyvinyl alcohol, a hydrophilic polymer that can be used as a wall-forming material in capsules [29], also nylon membranes have been used to encapsulate and trap enzymes such as: pepsin, pectin esterase for juice clarification, the invertase for sucrose investment. Another agent used in microencapsulation is chitosan, its use is quite wide in the food industry, it stands out as an antioxidant, antimicrobial, soluble protein recovery from surimi residues, covered for edible foods, renin for milk and casein coagulation to form artificial capsules [39].

Alginate is a polymer extracted from algae and used as an encapsulating agent; Its characteristics are: non-toxic, biocompatible, and ease of solubilization (by Ca ++ sequestrant). An example of alginates is that of calcium that has been widely used for the immobilization of lactic acid bacteria (BAL), the above due to ease of handling, non-toxic nature and low cost. Studies have shown that immobilized calcium alginate cultures are the best protectors, this has been evident by increasing the survival of bacteria under different test conditions than when the bacteria were tested in the non-encapsulated state [38]. The immobilization of bacteria in biodegradable microcapsules generates an adequate environment for their survival, temporarily providing protection of the immobilized bacteria from the environment, soil, competitors and predators.

For the preparation of alginate microparticles, distilled water containing 1% (w / v) sodium alginate, 5% (v / v) glycerol, 0.15% (v / v) xanthan gum and 0.1 is used % (v / v) of Tween 80, the above mixture is homogenized at 4 ° C for one day. The substance to be encapsulated is mixed with 500 mL of alginate solution and sprayed with 0.5 M CaCl2; the above allows beds to be formed using an air atomizing apparatus at a pressure of 1.0 kg f / cm2.

The microparticles are taken on a stand for 30 min for gelation and washed twice with distilled water; the capsules are separated by filter paper and dried by freezing [39]. Eudragit are a group of polymers derived from methacrylic acid that are available in different ionic forms. They are highly soluble due to their alkaline pH value, and by the neutralization of the carboxyl groups with the respective salt formation, and therefore, exhibiting the character of anionic polyelectrolyte in solution.

Different types of Eudragit have been used in the preparation of microparticles, allowing the release of active ingredients at the intestinal level, preventing the inactivation of drugs in the stomach, for example, in the preparation of microparticles that allow oral administration of peptides and proteins [24].

Lipids

Among the main lipid encapsulating agents are: milk fat, lecithins, waxes, stearic acid, monoglycerides, diglycerides, paraffins, hydrogenated oils such as palm oil, cotton and soy; they are excellent film formers capable of covering individual particles, providing uniform encapsulation [11].

Carbohydrates

They are extensively used in encapsulation, the spray drying technique is used for food ingredients as encapsulation support, within this broad group are starches, maltodextrins and gums [6-8].

Starch

Ingredient-based starches (modified starches, maltodextrins, b-cyclodextrins) are widely used in the food industry [8]; Among the most important starches are potato (Solanum tuberosum), corn (Zea mays), wheat (Triticum aestivum), rice (Oryza sativa), tapioca (Manihot esculenta) and inulin. The native and modified tapioca starch and maltodextrin has been investigated for its ability to be used as a wall material for the encapsulation of b-carotene. It has wide size distribution, compared to native starch and maltodextrin [40].

Maltodextrins

They are made by methods of acidic or enzymatic hydrolysis of starches. In the selection of wall materials to encapsulate, maltodextrin is a good solution between cost and effectiveness; It has low viscosity at a high proportion of solids, they are odorless, colorless and of low viscosity at high concentrations, they also allow the formation of free flowing powders without masking the original flavor, it is available in different molecular weights and are widely used in the food industry [3].

Gums

They are generally tasteless, but can have a pronounced effect on the taste and taste of food, are soluble, of low viscosity, have emulsification characteristics and are very versatile for most encapsulation methods [5]. Examples include locust bean gum, guar, tamarind gum, gellan gum and xanthan gum; applicability has been in bacterial cell immobilization, for which alginates and carrageenan have been used. Gum arabic, a biodegradable natural polymer has been used as a matrix to encapsulate enzymes such as endogluconase produced by the Thermomonospora bacteria.

The endogluconase showed a change in the optimum temperature (50-55 ° C) and a considerable increase in pH and stability compared to the free enzyme, in addition it also protected the activity of the enzyme in the presence of detergents enhancing the shelf life. Mixtures of gum arabic and maltodextrins have also shown promise as solids transporters, providing viscosity for example in microencapsulation of cardamom oil by spray drying [2].

Proteins

Hydrocolloid foods are widely used as microencapsulants, for example: food proteins such as sodium caseinate, whey protein, soy protein isolates [18], waxes [11], gluten, grenetina, casein, soy, wheat and gelatin [7], the latter used for its good properties of emulsification, film formation, water solubility and biodegradability.

Antioxidants

Fat-soluble vitamins (for example, vitamin A, D, E, K and carotenes) and water-soluble vitamins such as vitamin C can be encapsulated using various technologies. For the encapsulation of vitamin C, cooling spray, freezing or cold bed coating can be used to later be added to solid foods, such as cereal bars, cookies or bread. Vitamin E or tocopherol shows good stability in the absence of oxygen; in contrast, the degradation rate of this vitamin is increased in the presence of molecular oxygen and can be especially rapid when free radicals are present, to avoid this degradation the tocopherol can be encapsulated protecting it against loss by oxidation during storage at 35 ° C by a period of less than 3 months using a hydrophilic matrix to obtain water soluble particles.

Once encapsulated, the addition of a-tocopherol (100 ppm) delays the oxidation of fish oil encapsulated in sodium caseinate with carbohydrates (25-50% w / w oil) ; however, additional measures (packaging, neutral atmospheres) are recommended. Apart from the encapsulation of oils, tocopherol based on sodium alginate microcapsules has been used as a natural material, resistant against simulated gastric fluid [39].

Microencapsules have been made from a large number of fruits and vegetables, for example: vegetable juices such as tomato, cucumber, carrot, lettuce, beet, spinach, celery and parsley [12].

Chemical Processes

Coacervation it consists of a separate polymer solute in the form of small liquid drops, which constitutes the coacervate. The deposition of this coacervate around the insoluble particles dispersed in a liquid forms incipient capsules, which by appropriate gelation gives the final capsules. It is a phenomenon that occurs in colloidal solutions and is considered as the original encapsulation method [9].The strategies to induce coacervation depend mainly on the physicochemical characteristics of the polymer and the center to be coated.

During coacervation, phase separation is induced by the slow addition of a "non-solvent" onto a solution of the shell forming polymer, the material to be encapsulated suspended. By "non-solvent" is meant that solvent that is miscible with the solvent of the polymer and in which the polymer is insoluble. As the non-solvent is added, insolubilization of the polymer is caused, which, in turn, is deposited around the particles present in suspension. At the end of the process, a high volume of the non-solvent is added in order to harden the microcapsules [28].

Generally, the core material used in the coacervation must be compatible with the polymer of the container and be insoluble (or barely insoluble) in the coacervation medium. This technique can be simple or complex. The simple technique involves only one type of polymer with the addition of strongly hydrophilic agents to the colloidal solution. The complex is characterized by being highly unstable to chemical agents, such as glutaraldehyde [22].For encapsulation this process has been extensively used for the production of microcapsules of polyvinyl alcohol, gelatin-acacia and several other polymers [23].

Co-crystallization It is a microencapsulation process where two ingredients are incorporated into a porous conglomerate of sucrose microcrystals formed by spontaneous crystallization. The processes are carried out by concentration of sucrose syrups until supersaturation. This is achieved with constant agitation of the material to be encapsulated; this allows nucleation and agglomeration of the product [16].

Interfacial polymerization. In this process the polymerization of a monomer takes place at the interface of two immiscible substances, forming a membrane, which will give rise to the wall of the microcapsules. This process takes place in three steps:

- Dispersion of an aqueous solution of a water soluble reactant, in an organic phase to produce a water-in-oil emulsion
- Formation of a polymeric membrane on the surface of water droplets, initiated by the addition of an oil-soluble complex to the previous emulsion.
- Separation of the microcapsules from the organic phase and their transfer in water to give an aqueous suspension. The separation of the microcapsules can be carried out by centrifugation.

The selection of the encapsulation method is a function of: the average particle size required, the physical properties of the encapsulating agent, the substance to be encapsulated, the applications of the proposed encapsulated material, the desired release mechanism and the cost [40].

Mechanical Processes

Spray drying. Microencapsulation by the spray drying method is the most common method of encapsulating food ingredients, as examples are: vitamins (C, E), folic acid, aromas, oregano, citronella, cardamom oil, probiotic bacteria, lipids, linoleic acid, vegetable oils; minerals such as iron; anthocyanin and milk pigments among other foods. This method is the most used in the food industry because it is the most economical than the previous one of co-crystallization to conserve nutrients, easy equipment availability, low processing costs, good stability of the final and flexible product [33].

Compared to other methods; spray drying provides relatively high encapsulation efficiency. The highest encapsulation efficiency achieved with spray drying is between 96 and 100%, higher values compared to other methods [21].Among the most important parameters to control during spray drying are: the inlet and outlet temperatures of the drying air, the feed flow of the product to be dried, the residence time and the conditioning of the raw material [11].

In this regard, the spray drying process involves three stages: preparation of the dispersion or emulsion, homogenization and atomization. This process consists of atomizing the material that is in a liquid state, either as a solution or as a dispersion, finally forming fine drops on a heated gas stream, when the small drops of the liquid make contact with the gas, and at a higher temperature, a rapid evaporation of the solvent occurs, forming a thin film of the coating material found. In this method the component or substance to be encapsulated is surrounded by a protective matrix, usually a polymer such as acacia gum, maltodextrin, starch and carbomethylcellulose [41].

This technique can be applied to water-soluble materials, fish oils fixed on a solid carbohydrate matrix (modified starch, maltodextrin, cyclodextrin), natural pigments, starch as support material, probiotic cell concentrate and milk powder. For this last case before spray drying, the milk is usually heated, evaporated and homogenized, decreasing the size of the fatty globule and inducing interactions between proteins and fatty globules. Although several types of atomizers are used in spray drying, nozzle pressure atomizers and rotary disk atomizers are exclusively used for spray milk drying [31].The merits of this process are the availability of equipment, low cost of processes, good retention of volatiles, good stability of the final product and large-scale production in continuous mode. Spray by cooling or freezing.

This method is considered one of the most suitable for drying biological materials and sensitive foods [41]. Spraying by cooling and freezing involves dispersion of water soluble ingredients in a molten grease or wax; this dispersion is carried out through injectors with heating inside a chamber at room temperature or cooling temperature; if the chamber is at room temperature, the encapsulation material would have a melting point between 45 and 122 ° C and if the chamber is cold, the materials would melt at 32-42 ° C and can be used.

The microcapsules are insoluble in water, which is why their content could be released when the temperature of the food product rises above the melting temperature of the fat or wax [22].A variant of spray drying consists of cooling or freezing, where the material to be encapsulated is mixed with the carrier and is atomized by means of cold air. The microcapsules are produced by nebulization of the emulsion or suspension containing the wall material and the active substance can be solid or liquid.

The covers used are usually vegetable oils, in this way heat-sensitive liquid and materials that are not soluble in conventional solvents can be encapsulated. The temperature reduction produces a solidification of the wall lipid and the entrapment of the active substance in the center of the capsule. Cooling spray is usually used to encapsulate chemical compounds such as ferrous sulfate, vitamins, minerals, acidulants, flavors and aromas, bakery products, powder soups and foods containing a high level of fat [12].

The selection of the encapsulation process for an application considers the average particle size required, the physical-chemical properties of the encapsulating agent and the substance to be encapsulated [5].In freezing spray, the roofing material is melted and atomized through a tire nozzle in a glass, usually it contains a carbon dioxide (CO_2) ice bath (temperature -50 ° C) in a fluidized bed melted

Thus, the drops adhere to the particles and form a solidified cover film. These processes are suitable for the protection of some water-soluble materials, which may be differently volatilized or damaged during thermal processing [4].

The Controlled Release of the Capsules Consists of Three Stages:

- Initial release of the active substance bound to the surface or embedded in the surface region of the M.E.
- Diffusional release of the active substance through the polymer matrix and through the pores during degradation of the matrix.
- Erosional release of the active substance by the disintegration of the polymer matrix and dissolution after the matrix loses its integrity and the polymer chains are degraded to a size small enough to be solubilized.

There are several factors that affect the release of the active substance from these systems. Among them are the composition and molecular mass of the polymer, the content of active ingredient, the size and porosity of the microspheres and the physical-chemical characteristics of the active substance [13].Quality of the capsules obtained by encapsulation methods.

The product obtained analyzes are performed to verify its quality, within these analyzes are: ash, moisture, hygrospicity, solubility, aqueous activity, process performance, morphology and size of the microcapsules, color stability, sensory analysis, weight, density, unit encapsulation and cell distribution [19]. Future Trends Microencapsulation is recommended for applications in the food industry; a significant increase in this industry has been observed in recent years. This technique will play an important role in the very near future; this is why some research companies and institutes are looking for new ingredients with possible healthy benefits. Phytochemical ingredients, wood-derived ingredients such as phytosterols, pro and prebiotics, new types of carotenoids, trace minerals and polyphenols, are examples of some compounds.

Many of these ingredients could be available in a purified form within the next 10 years; this will make it possible to improve the encapsulation processes. In addition to these purification systems, technological innovations will be required and with them new methods. Microencapsulation could certainly play an important role in these processes, although these will become more expansive to be used and bioavailable and could always be considered safe [41].

Conclusion

Encapsulation is a technique that allows the packaging of food, or materials such as oils, probiotic bacteria, enzymes, whey, plant pigments, minerals, vitamins and food additives. The main agents used to encapsulate are polyvinyl alcohol, alginates, lipids, carbohydrates, gums and proteins; This encapsulation is carried out through physical or mechanical processes; chemical processes include coacervation, interfacial polymerization, ionic gelation, polymer incompatibility, liposome entrapment, molecular inclusion and in the mechanical processes are co-crystallization techniques, freeze / cool drying, extrusion and finally there is the technique spray drying, this being the most important and used in the food industry.

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