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Nanoliposomes: Applications in Food and Dairy Industry

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Abstract

Food nanotechnology involves the utilization of nanocarrier systems to stabilize bioactive materials against a range of environmental and chemical changes as well as to improve their bioavailability. Nanoliposomes technology presents exciting opportunities for food technologists in area such as encapsulation and control release of food materials, as well as the enhanced bioavailability, stability and shelf life of sensitive ingredients. In this paper ,the main concept of nanoliposomes, mechanism, types are described with their potential applications in food ,dairy and other such as in cancer therapy, vaccine production and in cosmetics.

Keywords: Nanoliposomes, MFGM (Milk Fat Globule Membrane), Vesicles, Bioavailability, Virosomes

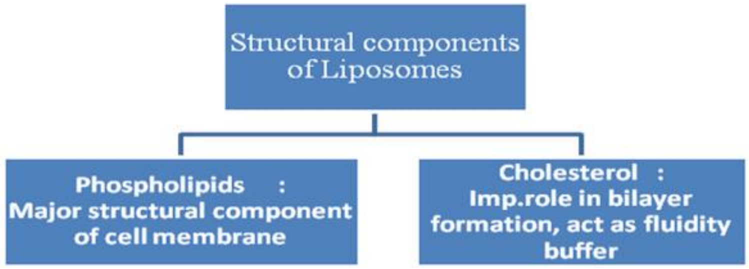
Introduction

What is Liposomes and Nanoliposomes??

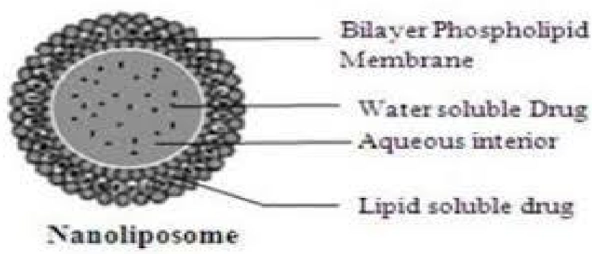
A recent definition proposed at a conference in the field of liposomology, describes liposomes as “closed, continuous bilayered structures made mainly of lipid and/or phospholipid molecules”. Liposomes are simple, microscopic, concentric, bilayered vesicles in which an aqueous volume is entirely enclosed by a membraneous lipid bilayer mainly composed of natural or synthetic phospholipids.

Liposomes were first produced in England in **1961** by Alec **D.Bangham**

Manufactured by using safe ingredients -- from natural sources, such as egg, soy, milk and breast milk. There are a large number of potential opportunities for use of liposomes in the food industry, but the high cost of the soya and egg phospholipids used by the pharmaceutical industry has limited their commercial application in food systems. So liposome prepared from milk MFGM is effective. (Thompson *et. al*., 2007).



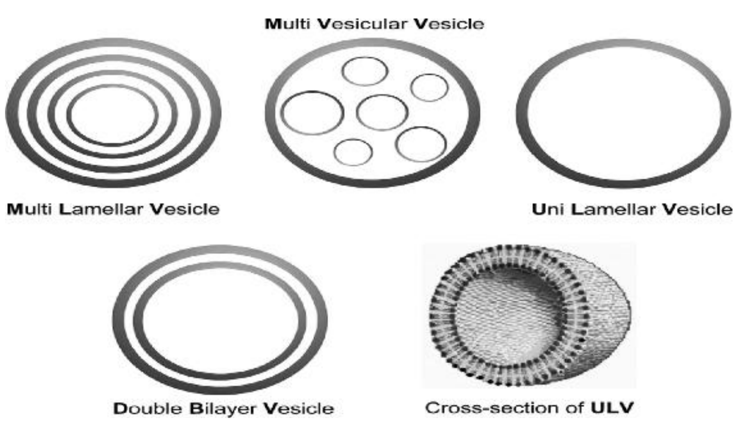
Nanoliposomes, or nanometric versions of liposomes, are colloidal structures formed by the input of energy to a right combination of constituent molecules (mainly phospholipids) in an aqueous solution.



Main types of liposomes and their Characteristics.

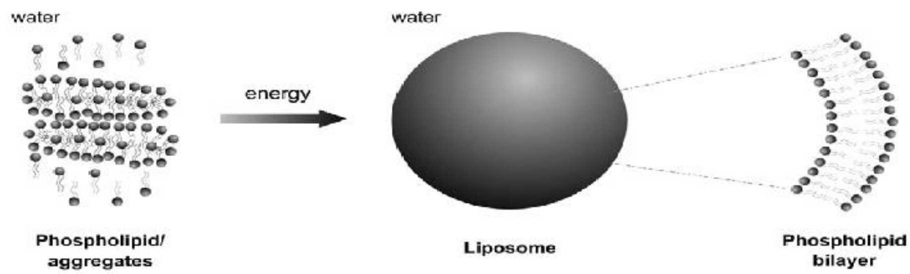
Vesicle T ypes	Abbreviated name	Diameter	Number of bilayers
Small unilamellar vesicles	SUV	20–100 nm	1 Lipid bilayer
Large unilamellar vesicles	LUV	>100 nm	1 Lipid bilayer
Double-bilayer vesicles	DBV	>100 nm	2 Bilayers
Multi lamellar vesicles	MLV	>0.5 μm	Approximately 5–20 lipid bilayers
Oligo lamellar vesicles	OLV	0.1–1 μm	Approximately 5 lipid bilayers
Multi vesicular vesicles	MVV	>1 μm	Multicompartmental structure

(Mozafari *et.al*.2008)



Mechanism for the formation of liposomes and Nanoliposomes

When amphiphilic molecules such as phospholipids are placed in an aqueous environment, they form aggregated complexes in an attempt to shield their hydrophobic sections from the water molecules while still maintaining contact with the aqueous phase via the hydrophilic head groups. If a sufficient amount of energy is provided to the aggregated phospholipids, they can arrange themselves in the form of organized, closed bilayer vesicles (i.e., liposomes or nanoliposomes). During this process, liposomes can entrap hydrophilic solutes that are present in the hydration media. Lipophilic molecules, or lipid-soluble compounds such as certain vitamins, nutrients, and drugs, can also be incorporated into liposomal bilayers by dissolving these molecules together with the lipids.



A simplified mechanism for the formation of liposomes and nanoliposomes

Methods of Preparation of Nanoliposomes:

The following are types of mechanical dispersion methods:

a) Micro- fluidizer
b) Sonication
c) French pressure cell: extrusion.

Applications of Nanoliposomes related food and dairy industry:

1. Applications in the Food Industry

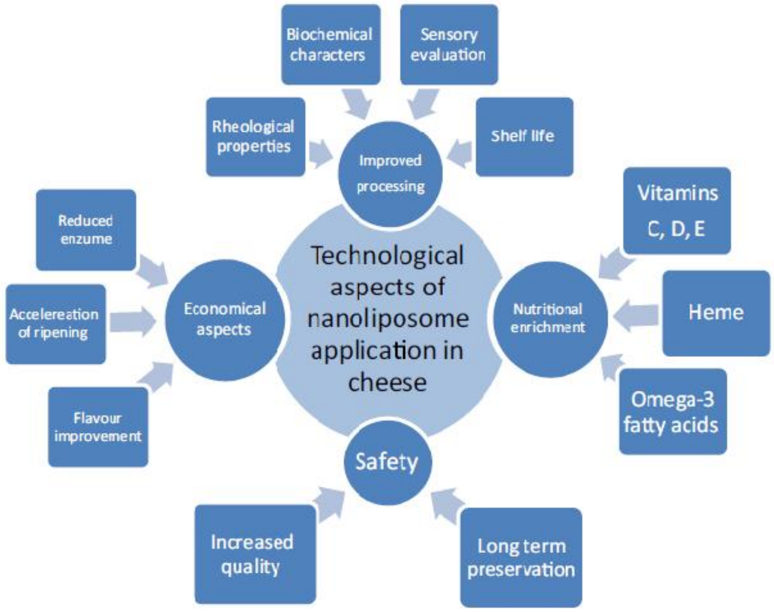
The main applications, so far, have been aimed at altering the texture of food components, encapsulating food components or additives, developing new tastes and sensations, controlling the release of flavors, and increasing the bioavailability of nutritional components (Chaudhry *et. al*., 2008).

The majority of encapsulation techniques currently employed in the food industry are based on biopolymer matrices composed of sugars, starches, gums, proteins, synthetics, dextrins, and alginates (Taylor et al., 2005). However, liposomes have recently begun to gain in importance due to their aforementioned unique advantages .Based on the results of liposomal studies in the pharmaceutical and medical research and applications (e.g., drug delivery, cancer treatments, gene therapy, etc.), food scientists have begun to utilize liposomes for the controlled delivery of functional components, such as peptides, enzymes, vitamins, and flavors in various food applications (Taylor *et. al*., 2005).

2. Applications in the dairy industry

Application in the cheese manufacturing

Nanoliposomes is one method for acceleration of cheese ripening .For proper ripening, enzyme release must be progressive and controllable .Nanoliposomes have well defined behavior and release pattern.Various enzymes can be encapsulated. Entrapment efficiencies with flavourzyme, proteases and palatase M were 20.2%, 33% and 35.9%, respectively. (Kheadr *et. al*., 2002)



3. ***Nanoliposomal Nisin*****:** Late blowing: major problem in cheese .Nisin prevents late blowing

- Nanoliposomal nisin increases the efficacy against *listeria* spp.
- 3-log and 1.5-log reduction in the counts of *L. monocytogenes* and *L. innocua*, respectively (Taylor *et al*., 2008)
- Entrapment efficiency (EE) of nisin depends on nisin concentration and pH.

Potential advantages of nanoliposomal nisin:

- Reduces nisin affinity to nontarget components
- Acts as long term preservative i.e. increases stability and availability
- Protects nisin from inhibitors
- Decreases the risk of emergence of resistant strains
- Provides a mean for targeting the bacteria

4. ***Nanoliposome Encapsulation with Donkey Milk Bioactive Proteins*** and Its Possible Application in Dermatology and Cosmetics. Study was conducted to establish encapsulation efficacy of nanoliposome loaded with skimmed donkey milk and to explore the efficiency of encapsulation of different skimmed donkey milk concentrations in nanoliposomes. (Kocic *et*. *al*. ,2017)

5. ***Encapsulation of Antioxidants***

A typical example of nanoliposome application in food area is the encapsulation of antioxidants, which possess many health effects, as well as retarding the oxidation (degradation) of nutrients in foods.These important classes of bioactive compounds possess very limited ability to cross cell membranes and are rapidly cleared from cells. A possible method for the protection of antioxidants and enhancing their bioavailability is to employ nanoliposome technology.

Antioxidants may be utilized for two main purposes, to protect the sensory and nutritive quality of the food and/or to protect the body against certain diseases. Further more, oxidative degradation can be increased if the lipid is incorporated into food emulsions such as margarines, spreads, and salad dressings, since the aqueous phase can allow the rapid transmission of oxidants such as oxygen and metal ions. These problems can be minimized by incorporating antioxidants into the lipid phase of liposomes, however, the most effective antioxidants are synthetic and there is increasing pressure to phase these out. (Mozafari *et al*., 2007)

6. *Lactose Intolerance:* Liposomes have also been used in dairy products to induce the slow digestion of lactose to aid the digestion of dairy products from the lactose intolerant. (Matsuzaki *et al*., 1989).

7. *Other applications:*

1. Nanoliposome in nanotherapy.

Nanocarriers have the potential to increase solubility, enhance bioavailability, improve time-controlled release and facilitate precision targeting of the entrapped compounds to a greater extent due to more surface area (Mozafari *et al*., 2007).

2. Cancer therapy

Liposomes are used as a carrier for drugs in the treatment of cancer and are beneficial because the liposomes promote passive targeting for the cancer cells. Unlike the blood vessel cells in healthy humans,tumor cells have an enhanced permeability and retention effect, allowing the passage of larger molecules. Drugs encapsulated with liposome up to the size of 400nm can enter tumor sites easily but are restricted from the healthy tissues by the endothelial wall. Thus, the drug molecules are targeted to the tumor cells other than healthy tissues in the body. (Md. Shivli Nomani and Jeyabalan Govinda Samy , 2016).

3. Application in vaccines production

The vaccines produced by liposomal method is also known as virosomes (Wilschut J., 2009), that are constructed with viral surface antigens and synthetic lipids such as DOPC, DOPE or DPPC, which simulate viral membrane for vaccine delivery. When compared virosomes with conventional vaccines, virosomes exhibit the excellent immunogenicity as well as better biocompatibility and safety. These two liposomal vaccines, Epaxal and Inflexal V, have been permitted for clinical use. (Usonis V *et. al.*, 2003).Epaxal is a hepatitis A virus (HAV) vaccine. Inflexal V is an influenza vaccine which has been used worldwide for fifteen years. In a clinical study involving 453 children, Inflexal V achieved a significantly higher seroprotection rate (88.8%) for H_3N_2 virus than that of a conventional influenza vaccine (78.3%), indicating the better immunogenicity.

4. Application in cosmetics

Now a day nanotechnology being used frequently in skin care goods. It is rapidly becoming a common in medicine and skin care products. It has poor reorganization what the technology, benefits, or possible implications of its use. The type of nanotechnology that is most significant in cosmetics, skin care and health products is the use of nanoparticles. Nanoliposomes are one of the most recognized technologies for the nanoparticles used in skin care and cosmetic products.
(Fakhravar *et.al*., 2016)

Conclusions

Nanoliposomes offer a versatile approach for the encapsulation, protection and controlled release of sensitive bioactives.Special interest for the food industry is the fact that they can be prepared from naturally occurring food materials egg, soy, milk and breast milk. Nanoliposomes are ideal systems for encapsulation of sensitive ingredients. In order to extend the degree of utilization of liposomes, future research has to focus on the production of lipid vesicles through safe, scalable methods by using low cost ingredients.Another research and development area, which has remained relatively unexplored, is that of encapsulation of antimicrobials for the protection and preservation of foodstuffs. The goal is to demonstrate the true potential for antimicrobial – loaded liposomes and nanoliposomes to improve the quality and safety of a wide variety of food products.

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