Perspective

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Nano-delivery system for bioactive compounds

Abstract

The scientific community is searching, discovering and inventing things for the welfare of humanity in pursuit of sustainable solutions to respective problems. Among the factors relating to human life, human health is the most concerned issue. Each country is investing a significant amount of money in research and development to improve the human health. Besides having appropriate amount of nutrients, the most important aspect of food is the bioavailability of nutrients. Food item rich in natural antioxidants but not accessible to human body is wasteful. Thus, nanotechnology has shown great potential to improve the efficiency of delivery system of bioactive components to the human body. In this article, an effort has been made to discuss the applications of nanotechnology in the delivery of bioactive compounds to improve the human health. Today, the pharmaceutical companies have started the manufacturing of nutraceuticals to treat the number of anomalies in human body. The nutraceuticals are the food, carrying densely packed bioactive compounds. The bioactive compounds help to fight against number of noncommunicable diseases such as cancer, diabetes, osteoporosis, arthritis and cardiovascular diseases. The action of bioactive compounds depends upon the extent of bio accessibility or bioavailability to the human body. In this context, nanotechnology play crucial role by manipulating bioactive compounds in the dimensions of 1-100 nm. The typical example of nano-delivery system is the liposomes, lipid vesicles, can incorporate variety of bioactive compounds in their interior. The exceptional capability of nanotechnology is paving a path of new technologies that may affect the human lives by various means. By improving the delivery efficiency of bioactive agents, nanotechnology can be a breakthrough technology in the world of food medicine.

Keywords: nanotechnology, bioactive compounds, delivery system, human health

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Introduction

Nanotechnology is the latest emerging branch of science that offers the multiple dimensions in providing the solutions of various problems. European commission recognized the "nanotechnology" as one of its six key enabling technologies that contribute to growth and competitiveness at various industrial scale.[1] Nanotechnology has helped to develop several technological improvements in the food science and technology such as formation of Nano emulsion, nanostructure, nanoparticles, Nano-delivery systems etc. On the other side, nanotechnology also revolutionizes the bio sensing area by improving efficiency and efficacy of sensing with nano-dimensional properties of materials.[2,3] Gold nanoparticles have shown great potential in detecting the specific meat in the meat products.[4] The properties of gold particles drastically change by reducing the size at nanoscale.[5] The need is the mother of invention. The main aim of every research is to provide the smooth track for the mankind. In the recent past, people have now become much aware and conscious about their health. In current scenario, the frequency of non-communicable diseases linked to lifestyle is being increased continuously. There may be certain reasons for the said problems viz., hectic daily schedule, altered food habits from natural to fast foods etc. It is the responsibility of scientists, engineers and technologists to provide the sustainable solutions of the respective problems. To boost their immune response and to combat the diseases, the people are looking towards the ayurvedic/natural solutions rather than the allopathic ones. Bioactive compounds with health promoting effects are attracting growing attention in this era of non-communicable diseases viz., cardiovascular diseases, type II diabetes and obesity.[6] Millions of pharmaceutical and biotech companies in India and abroad are engaging in manufacturing of bioactive compounds in different medicinal forms. For an overall improved consumer health, bioactive compounds are believed to combat aging, cancer and other noncommunicable diseases. The nano-phyto-bioactive compounds have also been tested to reduce the oxidative stress in Parkinson's disease models.[7] A variety of bioactive compounds are utilized for the treatment of several diseases viz., bergamot flavonoids obtained from *citrus bergamia* are used as antihyperlipidimic and antihyperglycemic agents in the human beings.[8] The principal flavonoids in citrus bergamia are characterized as neoeriocitrin, naringin, neohesperidin, bruteridin, melitidin, flavonoids 6,8-di-C-glicosides etc.[9] The bergamot polyphenols were found to show protective effects in doxorubicin-induced cardiotoxicity during Doxorubicin (DOXO) chemotherapy.[10] The efficacy of bergamot flavonoids could be improved by encapsulating it in nanostructure geometry that would probably save it from harmful enzymatic action and delivers the significant amount of compounds. The scientists and technologists are continuously putting efforts to increase the efficacy of bioactive compounds by improving the bioavailability in the human body.

To improve the bioavailability of the bioactive compounds, scientists evolved the concept of encapsulation viz., microencapsulation and Nano encapsulation. The implementation of nanotechnology has revolutionized the research and development in the biological systems. The nano-scale measurements changed the physical, chemical and biological behavior of particles. In order to successfully integrate bioactive ingredients in to food systems, structurally sophisticated encapsulation system must be engineered to ensure the maximum physical stability, protect ingredients against chemical degradation and enable the precise control of release of encapsulated components during mastication and digestion to optimize adsorption.[11] To achieve the targets as listed above, the nanoencapsulation system is the most advanced and robust type of delivery system to enhance the bioavailability of bioactive compounds. The research and development in the field of nano-delivery system has now taken a pace and various types of nano-delivery systems have now been made for the efficient delivery of different food ingredients including bioactive compounds. In recent years, extensive work has been done to check the feedback given by nanomaterials and nanoparticles for a number of pathophysiological situations. The scientists have made a number of nano materials for nano-delivery systems viz., PLGA (poly lactic co-glycolic acid polymer), micelle nanoparticle, oil in water nanoemulsion, biopolymer nanoparticle employed. Among the category of delivery systems, lipid-based nano-delivery system is the most efficient system for the delivery of bioactive compounds. Liposome is the typical example of lipid-based nano-delivery system. The liposomes are also employed for the delivery of topical drugs such as creams, foams, gels, lotions and ointments (Table 1).

Table 1 Nanomaterials for the delivery of bioactive ingredients

Nanomaterial	Function	Meat product	Performance in meat
PLGA nanoparticles (Phenolics loaded)	Antimicrobial	Raw and cooked meat systems	Efficient antimicrobial activity[12]
Micelle (naoparticle paprika oleoresin)	Encapsulation	Chicken breast fillet	Improved marinating performance and sensory perception[13]
Oil in water nanoemulsion (Sunflower oil)	Antimicrobial	Indo-pacific king mackerel steaks	Short lived antimicrobial[14]
Biopolymeric nanoparticle (Chitosan naoparticle)	Antimicrobial	Fish finger	Increased antimicrobial Activity[15]

Challenges of conventional delivery system

The challenges of conventional approach for integrating bioactive compounds such as curcumin, β-carotene, and fat soluble vitamins are their sensitivity towards oxygen, light, heat, pH, enzymes, low bioavailability etc. These factors ultimately affect the functionality of bioactive compounds present in the food matrix. This demands a suitable and well sophisticated delivery system to overcome the several limitations listed above. The nano-delivery system is the typical delivery system with efficient and controlled release of bioactive compounds.

Nano-delivery systems

Nanotechnology opens the door for the solution of various health problems viz., treatment of number of chronic human diseases by site specific and targeted delivery of drugs in precise amount.[16] There are two major types of liquid and solid nanodelivery systems. The liquid nanodelivery system includes nanoemulsions, nanopolymerosomes and nanoliposomes.[17] While the polymeric nanoparticles, nanocrystals and lipid nanoparticles are typical examples of solid nanodelivery systems.[18] The lipid based delivery system is the most advanced and robust type of nanoscale delivery system employed for the efficient delivery of bioactive compounds, drugs etc. The first nanotechnology based therapy with liposomes and micelles have now been approved by FDA.[19] The potential of nanotechnology is applied in liposomes to make it most efficient and the most potent nano-delivery system. Although, oils/lipids are sensitive towards heat, oxidation, light and moisture. Efforts are being made to improve the stability of oil/lipid based delivery system by making resistant to the above listed physical factors. Different technologies have been utilized to produce efficient nanoparticles with varying physical properties.[20,21]

Delivery system for bioactive compounds

The nanotechnology has made a significant contribution in the development of nano-delivery systems. This approach actually allows the encapsulation of bioactive compounds to withstand the negative impact of temperature, enzymes, pH during the processing of food.[22]

A number of materials including carbohydrate, protein, lipid and phospholipidsare employed for the nano-encapsulation of bioactive ingredients. The most stringent and successful type of delivery system are the liposomes and nano liposomes or nano lipid vesicles.

Liposomes

The concept of liposomes was first introduced by Bangham and coworkers in 1965 at Cambridge University. The liposomes are the spherical nano-sized vesicle consisting one or more phospholipid bilayers and acts as potential delivery systems for the drugs & other substances. Liposomes are biocompatible delivery systems for the bioactive substances, drugs and DNA.[23,24] They are colloidal particles made up of lipid bilayers encapsulating aqueous space. Liposomes structures are composed of lipid, phospholipids, protein and carbohydrate. Liposomes are classified into various categories on the basis of number of lipid layers and their size (Table 2).

Table 2 Liposomes and their features[24]

Types of vesicles	Number of bilayers	Diameter	Abbreviated name
Small unilamellar vesicles	One Lipid bilayer	20–100nm	SUV
Large unilamellar vesicles	One Lipid bilayer	>100 nm	LUV
Double-bilayer vesicles	Two bilayers	>100 nm	DBV
Multilamellar vesicles	Around 5-20 Lipid bilayer	>0.5μm	MLV
Oligolamellar vesicles	Around 5 Lipid bilayer	0.1-1μm	OLV
Multivesicular vesicles	Multicompartmental structure	>1 μm	MVV

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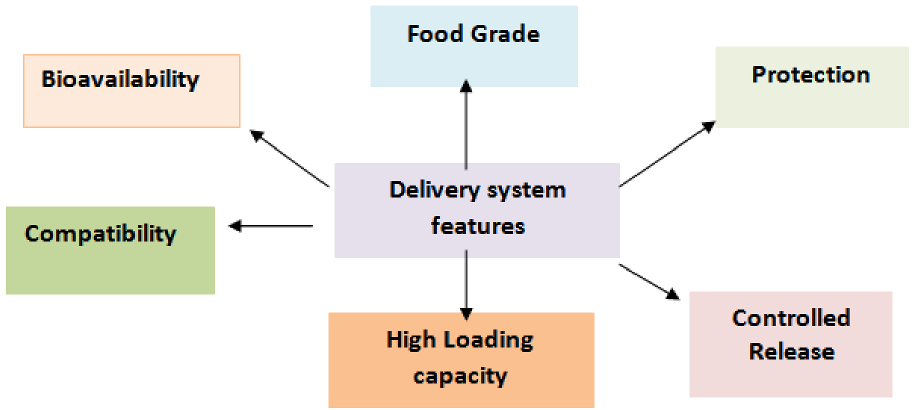

Figure 1 Typical features of delivery system for bioactive compounds.

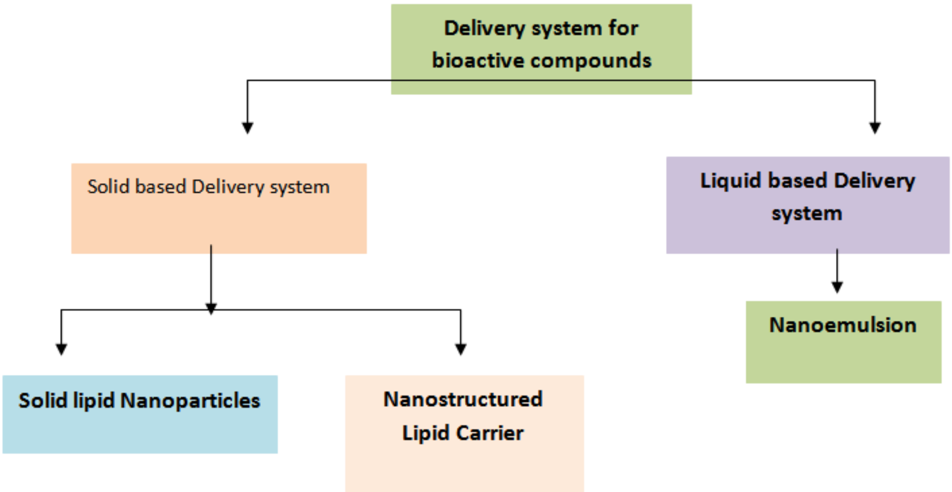

Figure 2 Types of delivery systems for bioactive compounds.

Liposomes effectively developed as vaccine adjuvants for cell mediated and humoral immunity as well. Liposomes are analogous to natural cell membrane. This property of liposomes made it biocompatible, safe for the utilization of clinical purposes. The unique features of liposomes have paved the path for the future researches in the field of science and technology starting from nanostructures to the delivery of bioactive ingredients.[25,26] There are several applications of liposomes in food and nutrition viz., protection of sensitive bioactive ingredients from the action of unwanted enzymes and acids for the efficient delivery of targeted molecules. The liposomes have also been employed as a delivery vehicle for the health promoting substances such as enzymes, vitamins and also for the efficient delivery of nutraceuticals and pharmaceuticals.[27,28,29] Further developments are going on to improve the efficacy of nano-delivery agents for the controlled and effective release of bioactive ingredients.

Conclusion

The present review briefly discusses the nano-delivery of bioactive compounds. The paper includes the fundamental information of nano-delivery system, their types and liposomes as the most potent delivery system. The variety of nanomaterials has been employed for the development of nanostructures as discussed in the paper. In the coming future, the nanofood will be very common along with the nanomedicine in the markets. There is the great probability that the patients will be more likely treated with the foods than the medicines in the coming future.

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Conflicts of interest

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