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# NANOEMULSION MATERIALS IN FOOD PACKING PROCESS: A REVIEW

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**ABSTRACT** Nanoemulsions are the microemulsions and prepared with the combinations of water in oil emulsion and emulsifiers. It has wide applications in food making and food processing. Nano emulsions have the property of antioxidant, anti-microbial, nutraceutical and pharmaceutical applications. The green synthesized nano emulsion materials are nontoxic and other medicinal properties and sometimes act as feed supplements. Owing its wide applications, green synthesized nano emulsions are an important food formulants for the recent years. This review describes the importance, synthesis and characterization methods of nano emulsions in food and food processing industries and various methods of nano emulsion preparations. Moreover, the green synthesis of nano emulsions and their significance in food and their processing is highlighted.

**KEYWORDS :** nanoemulsion, food processing, antioxidant, anti-microbial,

## INTRODUCTION

Nanotechnology has received great attention from researchers, scientists, and food processing technologists for application in the food and processing industry because of its promising outcomes. This is due to their increasing consciousness of their health and people are exploring healthy and nutritive meals in the food market worldwide. The exploitation of nanomaterials in food technology has given rise to various advantages in food packaging, functional food delivery, and nutraceutical manufacturing (Sneha et al., 2022).

Nanoemulsions are emulsions in smaller in size than microemulsions (Figure 1). They have special properties of small size, a greater surface area and less physical and chemical sensitivity, which make them ideal for food. Hence, in recent years more attention has been developed on nanoemulsion-based technological nano-food applications (Thirumalaisamy et al., 2022).

Food nano insecticide/nano pesticide, food nanoemulsion: antifungal and mycotoxin inhibitory nanoemulsion formulations are provided and improve the distribution of functional chemicals, such as colourants, flavouring agents, nutraceuticals, preservatives, or antimicrobial agents in foods. Food spoilage generally takes place with food-borne pathogens, food ingredients, biological agents, food intoxicants, vitamin-based edible nanoemulsions, natural antioxidants as delivery vehicles, and other factors are included. (Kasi Murugan et al., 2022).

In recent years, there has been a growing interest in the application of nanoemulsions in the food and beverage industries due to their better stability compared with conventional emulsions, higher liquid droplet interface area, optical transparency, and nanoencapsulation of bioactive compounds. Phytocompounds such as phenolic compounds, vitamins, carotenoids, and essential oils have recently attracted great interest in the formulation of phytocompound-loaded nanoemulsions. Nanoemulsions can effectively protect phytocompounds from adverse environmental conditions and improve their bioavailability and bioactivity, contributing to the enhanced physicochemical and functional properties of food products or the development of active coatings and films for food packaging (Danijel et al., 2022).In this article, we focus on the application of nanoemulsion-based delivery systems for improving the quality, safety, nutritional profile, and sensory attributes of muscle foods, such as meat and fish.

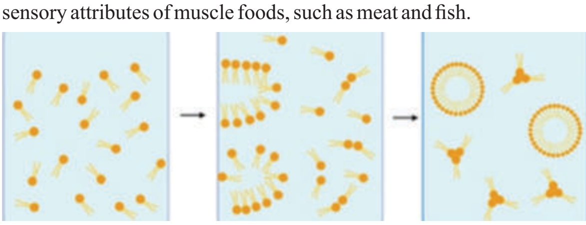

**Figure 1 Step Wise Spontaneous Emulsification Process**

### Nanoemulsion Preparation Technique

Nanoemulsion preparation by persuasion method (Figure 2) doesn't require any external force, but instead, it involves the formation of fine dispersions when phase transitions occur by changing either the temperature or composition while keeping the alternate parameter constant. High-pressure homogenization and micro fluidization methods are employed at both industrial and laboratory scales for attaining a very small size of nanoemulsion by utilizing high-pressure equipment. Various techniques employed for the preparation of nanoemulsion are shown in Table 1.

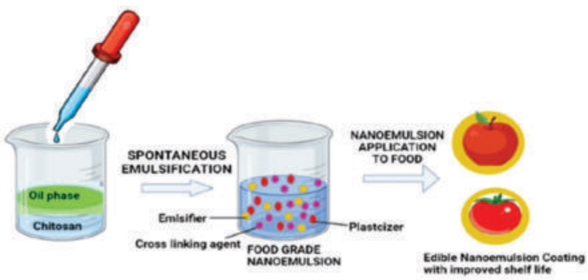


**Figure 2 Preparation Of Edible Food Grade Nanoemulsion To Improve Shelf Life And Quality Of Agricultural Food Products**

**Table 1: Techniques Employed For Preparation Of Nanoemulsions**

| Technique | Formulation | Conclusions |
|---|---|---|
| High pressure homogenization | Oral lipid nanoemulsion (primaquine) | Enhanced oral bioavailability, 10-200 nm particle size |
| High pressure homogenization | O/W nanoemulsions | Improved skin hydration and elasticity |
| Spontaneous emulsification | O/W nanoemulsion (aceclofenac) | Nanoemulsion with potential for transdermal delivery of aceclofenac |
| Spontaneous emulsification | Celecoxib nanoemulsion | Enhanced physical and chemical stability of celecoxib in nanoemulsion |
| High pressure homogenization | Lecithin-based nanoemulsions (progesterone) | Improved permeation rates of progesterone with long-term stability |
| High pressure homogenization | Prednicarbate nanoemulsion | Increased chemical stability of the drug in formulation |

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| Phase inversion composition method | Efavirenz nanoemulsion | Enhanced bioavailability, globule size <30 nm |
| High-pressure homogenizer | Dimethyl silicone dry nanoemulsion inhalation | Effective in acute lung injury, particle size of 19.8 nm |
| High-pressure homogenizer | Parenteral lecithin-based nanoemulsions (risperidone) | Enhanced brain availability of risperidone with a mean particle size of 160 nm |
| Microfluidization method | Pitavastatin-containing nanoemulsions | Enhanced permeation |
| High-pressure homogenization+ ultrasound | Nanoemulsion | Reduced energy demand for emulsification, low particle dimensions and higher stability |
| Sonication method | Saponin-stabilized quercetin-loaded o/w nanoemulsion | Stable for 45 d at RT, mean particle size of 52±10 nm |
| High-pressure homogenization | Paclitaxel-baicalein nanoemulsion | Strategy to overcome multidrug resistance |

## Application Of Nanoemulsions In Food

The technological limitations of developing functional foods are the low solubility, stability, and bioavailability of the bioactive compounds. Most bioactive food ingredients are susceptible to degradation during food processing and oxidative deterioration during storage (Xianquan et al., 2005; Shahidi and Zhong, 2010). Certain bioactive have low solubility but rapid metabolism which reduces their bioavailability, whereas some are volatile and sensitive to processing conditions (McClements and Li, 2010; Jin et al., 2016). The encapsulation of bioactive compounds can protect them from processing conditions and prevent their degradation for a long duration from temperature, light, pH, and oxidative conditions during storage. The application of a nanoemulsion-based delivery system for foods requires that the technique is economically feasible for industrial-scale production (Borthakur et al., 2016; Pathak, 2017).

## Encapsulation Of Nutraceuticals

Resveratrol, a natural polyphenol found in grape skins, blueberries, and raspberries has many functional properties such as antioxidant, anticancer, and antiobesity. Nanoemulsions-based delivery systems have been used to encapsulate resveratrol. Whole-fat milk was fortified with vitamin D3 nanoemulsions and was stable for 10 days against particle growth and gravitational separation (Golfomitsou et al., 2018).Astaxanthin, a dietary supplement is a light-sensitive molecule. Nanoemulsions have been formulated to photostabilize the pigment for its use in foods. The chitosan-coated and carrageenan-coated nanoemulsions of astaxanthin provided it protection from UV light and photodegradation (Alarcon-Alarcon et al., 2018).

## Natural Preservatives

Plant essential oils including thyme, oregano, clove and orange and their components such as thymol, carvacrol, eugenol, limonene, and cinnamon have strong antimicrobial activity against food-borne pathogens. Nanoemulsion formulations of essential oils can be used to overcome this problem and they can be used in foods as natural preservatives and food packaging (Alexandre et al., 2016).Oregano oil nanoemulsions inhibited the growth of food-borne bacteria Listeria monocytogenes, Salmonella typhimurium and E. coli O157:H7 on fresh lettuce. It was observed that oregano oil nanoemulsions disrupted bacterial membranes (Bhargava et al., 2015). Orange oil nanoemulsions inhibited spoilage of apple juice by Saccharomyces cerevisiae. Similarly, cinnamaldehyde nanoemulsions incorporated in pectin edible films inhibited the growth of E. coli, Salmonella enterica, Listeria monocytogenes, and Staphylococcus aureus. (Alexandre et al., 2016).

## Nanoemulsion-based Food Packaging Materials

Cellulose and its derivatives have been used to prepare edible films containing nanoemulsions of clove and oregano essential oils. Chitosan has been used for the preparation of nanoemulsion coatings and films of essential oils with antimicrobial activity such as carvacrol, mandarin oil, bergamot oil, and lemon oil. Sodium alginate was used to formulate films of nanoemulsion containing thyme, lemongrass, and sage essential oil. It was also useful in preparing films containing small, stable and less size-dispersed nanoemulsions of corn oil. (Alexandre et al., 2016). It has also been used to prepare films of rutin-encapsulated soybean oil. However, the nano-emulsified essential oil increased the water vapour permeability values resulting in poor water barrier properties. Basil seed gums have been used to prepare antimicrobial films of nano-emulsified Zataria multiflora essential oil (Gahruie et al., 2017).

## Current Perspectives And Future Prospects

In the last few years, several studies have been carried out to ascertain the advantages of encapsulation of lipophilic and functional compounds in nanoemulsions. Nanoemulsification is known to protect and increase the bioavailability of bioactive compounds as shown by in vitro studies. But there are limited studies which show the actual health benefits of including nanoemulsions in foods, their consumption, labelling, and public perception. Similarly, studies have been carried out to evaluate the use of high or low-energy approaches to formulate nanoemulsions and the focus is on optimizing processing parameters and ingredients used in nanoemulsion preparation. But there is not much research on reducing the cost of production of nanoemulsions as their preparation and application for fortifying and packaging in foods require higher energy input and equipment investment. Similarly, the risks associated with the use of engineered nanoemulsions in foods are not known. The potential toxicological effects and biological fate of nanoparticles after digestion have not been elucidated.

Nanoemulsions of bioactive compounds and functional food ingredients have great potential for applications in the food industries. The emulsion-based delivery systems and nanoemulsion edible coatings can improve the functionalities of food and also enhance their quality and shelf life. However, the food grade nanoemulsions can find widespread application only if their production cost is commercially feasible and meets the safety standards of the food industry. Therefore, it is important to optimize the bioactivity of the encapsulated components for scaled-up production. Further studies should focus on the biological events and risks associated with the use of nanoemulsion-based delivery systems in food products and packaging applications for ensuring the safety of the consumer.

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