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Nanoemulsion: Food quality and safety in meat and vegetable products

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Abstract

Faced with the growing demand for healthier and safer food products, it is of great interest to implement new approaches based on nanotechnology to improve the quality of food products and food safety. One of the relevant applications in this field is the use of nanoemulsions in the meat, fruit and vegetable industry. Many active ingredients are used to preserve quality and provide nutritional benefits to food products, such as antimicrobial activity through nanoemulsions containing essential oils. This study has been carried out to give an overview of the role of nanotechnology highlighting the alternative approach to the use of edible coatings based on nanoemulsions in food products. In addition, it emphasizes recent advances to improve the quality and shelf life of food products**.**

Keywords: *Nanoemulsion, nanotechnology, meat products, food safety. food safety*

1. Introduction

Nanoemulsion technology is particularly suitable as delivery and encapsulation systems for functional compounds, which have more potential advantages than conventional emulsions (1). Nanoemulsions are defined as emulsions composed of nano-sized droplets dispersed in another immiscible liquid that exhibit properties that distinguish them from conventional emulsions and make them suitable for encapsulation, release, and formulation of bioactive ingredients in different fields, including medicines, food, and farming. (2) Nanoemulsion can act as management systems for relevant functional compounds such as antioxidants, antimicrobials, nutraceuticals, drugs, and flavors (3,4). The food industry has made important advances with the application of nanotechnologies, such as nanoliposomes, nanoemulsions, nanofibers and nanocapsules, to obtain freshness and better taste of food (5). Nanoemulsions are colloidal systems of particular interest because they can be made from food grade ingredients and use processes in the food industry, such as mixing, heat treatment, and homogenization (3). The food industry uses these emulsion science and technology principles to create and transform a wide variety of foods and beverages (6). One of the main advantages of using nanoemulsions is that the food manufacturer can improve some properties, such as appearance, texture and / or taste, through a careful selection of the ingredients and the processes used for their preparation (7). Most studies indicate that nanoemulsion is the most promising approach to improve the quality attributes of meats, fruits and vegetables, because it is capable of encapsulating antioxidants, antimicrobials, nutraceuticals, color and flavor as nanocarriers (8, 4).

2. Nanoemulsion and its preparation

Generally, a nanoemulsion is a colloidal dispersion consisting of 2 immiscible liquids, which are typically oil and water in food applications, where one of the liquids disperses in the other as fine droplets (8). The primary parameter that distinguishes emulsions from nanoemulsions are the magnitudes of the droplets with a mean droplet diameter in conventional emulsions ((d > 200nm) that is larger than in nanoemulsions ((d < 200 nm). However, the two systems are thermodynamically unstable, that is, the independent energy of the separate oil and water stages is less than the nanoemulsion.

A classic nanoemulsion has an oil stage, a water stage and an emulsifier. Thanks to the nano-sized droplets (10-1000 nm), nanoemulsions present various benefits. For example, nanoemulsions are radically stable to gravitational division because the minute particle magnitude ensures that the effects of Brownian displacement dominate gravitational forces.

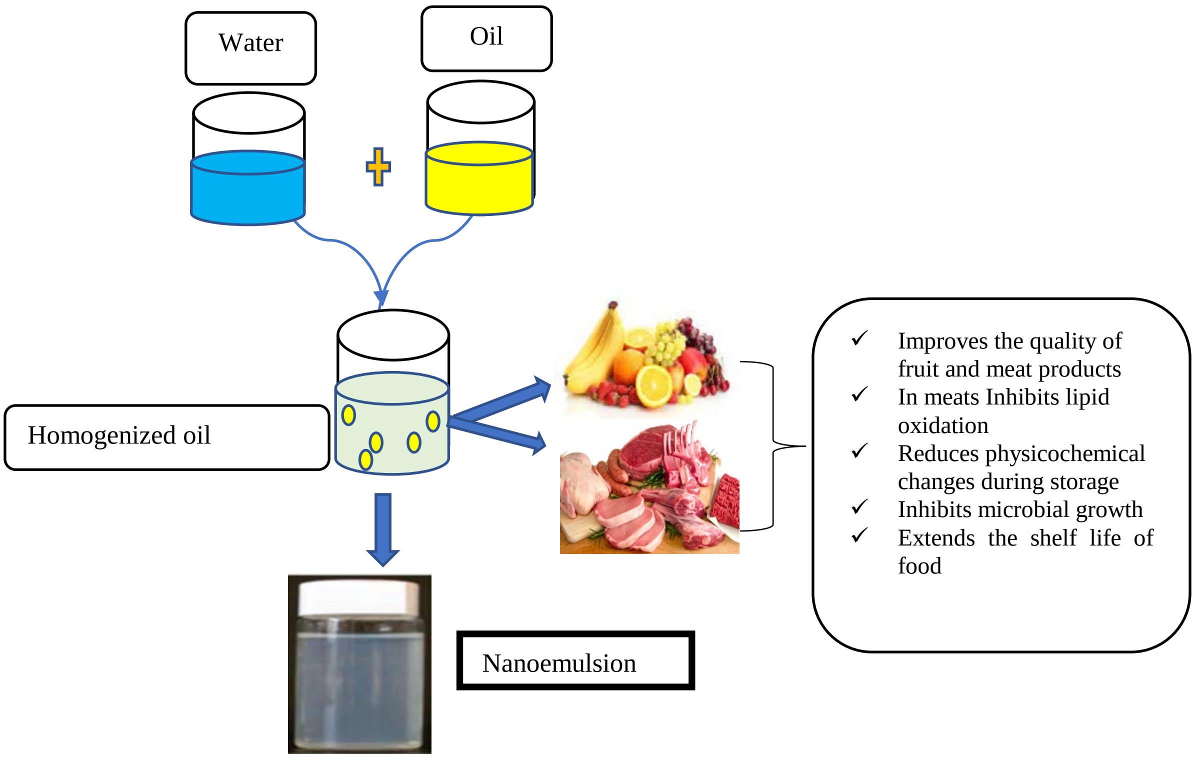

Figure 1: Schematic diagram of nanoemulsion formation using the oil phase and the aqueous phase using a high energy approach.

3. Biological activity of the nanoemulsion

The biological activity of the nanoemulsion can be enhanced by encapsulating compounds with better reactivity and better transfer of molecules through fruit and vegetable membranes (9,10). Despite these benefits, the long-term equality of nanoemulsion is a fundamental constraint that limits its wide application. Nanoemulsions are thermodynamically unfavorable systems thanks to the positive independent energy accompanied in the construction of the oil and water interface, therefore, they tend to decompose over time through mechanisms of flocculation, coalescence, Ostwald ripening and gravitational division. These mechanisms remain involved with the various forces in systems, such as repulsion between particles, attractive forces, gravitational forces, and flow forces (8). To avoid the immediate degradation of the nanoemulsion thanks to these mechanisms, various stabilizers, emulsifiers or food-level surfactants are commonly added to this system (4).

Surfactants have the possibility of being (I) ionic (negatively or positively charged) such as for example sodium lauryl sulfate, diacetyl tartaric acid ester of mono and diglycerides, citric acid esters of mono and diglycerides and lauric arginate; (II) nonionics such as sugar monopalmitate, sorbitan monooleate, Tween-20 and Tween-80 at 20, 40, 60 and 80; and (III) bipolar such as phospholipids. Studies report that high molecular weight polysaccharides have the possibility of being used as surfactants or carriers that support the active agents applied to improve the functionality of coatings (11).

The nanoemulsion can be constructed using 2 different approaches: high energy procedures and low energy procedures. High-energy procedures apply intense disruptive forces to break macroscopic droplets into small droplets and are capable of intermixing immiscible liquids using mechanical devices such as high-pressure homogenizers, microfluidizers, and sonicators (8). Alternatively, low energy processes are subject to the spontaneous formation of small droplets within the mixed oil. - water - emulsifying systems once solution or environmental conditions are altered. Low-energy procedures integrate spontaneous and reversal-stage procedures. The stage inversion procedure is based on a stage inversion structure if the nanoemulsion generation is dependent on the dilution process of the water or oil stage, and the stage inversion temperature if the nanoemulsion generation is dependent on the changing temperature (12).

After formation, some characteristics of the nanoemulsion, such as the magnitude, structure, equality and morphology of the droplets, are characterized by techniques such as dynamic light scattering, multiple light scattering, microscopy, calorimetry of differential scanning, X-lightning diffraction or infrared spectroscopy. Technical microscopy that includes transmission electron microscopy (TEM), scanning electron microscopy (SEM) and atomic force microscopy (AFM) is used primarily to obtain data on the microstructure of the nanoemulsion (13; 14). Other procedures such as Differential Scanning Calorimetry (15) and X-Lightning Diffraction (16) have the possibility to use to identify stage transitions and examine the proportion of solid fat or ice crystals, the crystallographic composition, the physical characteristics and the chemical structure of materials. Fourier transform infrared-based technique can measure the proportion of elements in a mixture and decide the consistency or quality of a sample (13, 16).

4. Applications of nanoemulsion technology

Nanoemulsion technology can also be combined with other tactics to improve the quality or effective life of foods from the meat, fruit and vegetable group by working with an obstacle technology approach. For example, Chouliara, Karatapanis Savvaidis and Kontominas (2007) (17) combined oregano oil nanoemulsions with modified atmospheric packaging to increase the effective life of fresh breast chicken under refrigeration conditions. In other studies, nanoemulsions have been combined to increase the effective life of meat foods, exemplifying nanoemulsions of cinnamon oil and soy ribbons (18) and cinnamaldehyde nanoemulsions with corn starch ribbons (19). The emulsified fundamental oils have also been combined with chitosan nanoparticles to improve their activity in meat patties (20). In a current analysis, a mixture of 2 natural bioactive substances, rosemary extract and ε-poly-L-lysine, was incorporated into nanoemulsion formulations to improve their characteristics.

Antimicrobials and antioxidants.

Plants naturally generate a variety of secondary metabolites to defend themselves from their environment, such as exposure to sunlight, oxygen, heat, gel, or pests. Several of these phytochemicals have antioxidant or antimicrobial activity and therefore have the possibility of being used as natural preservatives in food. Fundamental oils isolated from various plant sources have been shown to be potent antimicrobials against a wide spectrum of foodborne pathogens and spoilage organisms (21). Furthermore, encapsulation of such essential oils in well-designed nanoemulsions can improve their safety, ease of use, and effectiveness (22). Various researchers have reported that the important oil encapsulated in nanoemulsions has an intense antimicrobial and / or antioxidant activity, the oils of cinnamon and thyme being integrated into the meat patties.

Impact on microbiological stability

Meats

Meat and fish are highly perishable and, in most cases, cannot be stored for longer periods. These products are rich in nutrients and have a high moisture content and a moderate pH, which makes them especially sensitive to microbial contamination (23, 24). As a consequence, innovative tactics to inhibit contamination or microbial growth continue to be explored, with the aim of increasing their effective history (25). In particular, there has been great interest in using nanoemulsions to produce natural antimicrobial treatments for this class of products (26).

It is estimated that several of the hydrophobic antimicrobials used in nanoemulsion-based systems show their effectiveness by interacting with the cell membranes of microorganisms, thus inhibiting their convenient handling (27). In addition, they have the potential to interfere with key proteins in cell membranes or the cytoplasm that are needed for the cell to function properly (28). This class of antimicrobial nanoemulsion was shown to exhibit a broad spectrum of activity against Gram-positive and Gram-negative bacteria (29)

The application of essential oil nanoemulsions as antimicrobials in a variety of food systems has been inspected in detail elsewhere (4). On some occasions, the active elements of nanoemulsions have the possibility of being released little by little during storage, thus giving an antimicrobial and antioxidant activity over prolonged periods (30). Similarly, coatings containing ginger oil nanoemulsions exhibited antioxidant and antimicrobial activity in chilled chicken fillets (31). Recently, it was shown that fundamental oil nanoemulsions formulated from Z. multiflora and Bunium persicum Boiss oils significantly decreased the increase in total viable bacteria, total psychrophilic bacteria, Pseudomonas spp., Enterobacteriaceae, lactic acid bacteria, yeast and mold on turkey meat (32).

Fruits and vegetables

Salvia-Trujillo et al. (2015a, 2015b) studied the effects of nanoemulsion-based food coatings (concentrations of 0.1, 0.5 and 1% (v / v) of important lemongrass oil) on freshly cut Fuji apples and found complete inhibition of the natural micro flora throughout 2 weeks of conservation. life using concentrations of 0.5 and 1% major oil. Radi et al. (2018) (33) investigated the effects of microemulsion and nanoemulsion-based food coatings containing 0.5 and 1% important orange peel oil on the microbial quality of orange slices and observed that the coated sample microemulsion (1% important orange peel oil) and nanoemulsion (0.5% substantial orange peel oil) had a lesser bacterial increase than the control. It was concluded that the measurement of the emulsion droplets and their concentrations were effective in reducing the microbial growth.

The nanoemulsion has been formulated with the integration of 0.3, 0.5, 1, 2 or 3 gram / 100 gram of lemongrass oil in a carnauba wax solution by Kim. et al. (2014) (34) for the coating of grape berries. The results showed the reduction of Salmonella typhimurium and Escherichia coli O157: H7 well over 3.2 and 2.6 log CFU / gram, respectively, throughout an effective life of 28 days at 4 and 25 ° C. The effects Inhibitors mainly increased while the concentration of lemongrass oil increased from 0.3 to 3 gram / 100 gram. No inhibition was seen in the coated product without lemongrass oil nanoemulsion. Jo et al. (2014) (28) reported that apples coated with nanoemulsion containing lemongrass oil inhibited the population of *Escherichia coli* O157: H7 and *Listeria monocytogenes* compared to uncoated apples over 5 months of storage. Furthermore, the yeast and mold population in uncoated apples was 2.2 log CFU / gram, as yeast and mold were not detected in coated apples. Martínez-Hernández et al. (2017 (35) and Tastan et al. (2017) (36) noted that carvacrol-loaded nanoemulsion coatings were quite effective in minimizing microbial activity in freshly cut carrot slices and cucumber slices than the uncoated control. Results were also monitored by Bhargava. et al. (2015) (37) once fresh lettuce was coated with 0.1% oregano oil-based nanoemulsion and by Zambrano-Zaragoza et al. (2014) (38) for freshly cut apples coated with nanoemulsion that include a- tocopherol.

Impacto en los atributos sensoriales

It is essential that any nanoemulsion-based management system does not adversely affect the desirable sensory attributes of the foods such as the meats, fruits and vegetables in which they are used. Nanoemulsions loaded with different active compounds have been reported to influence the sensory attributes of foods in both meats, fruits and vegetables. For example, olive oil nanoemulsions were shown to mask the deep fishy odor of rainbow trout throughout storage, while having a positive impact on sensory qualities such as taste, odor, and texture (39). Furthermore, the application of nanoemulsions did not adversely affect the taste and aroma of the fish fillets, which were actually more favored by the sensory panelists than by the control. Other studies have shown that nanoemulsions of rosemary, bay leaf, thyme, and sage oil improved the sensory attributes of fish fillets and increased their effective history (30, 41). Covering the patties with starch ribbons containing antimicrobial nanoemulsions did not adversely affect their taste, odor, color, and overall acceptability, which was attributed to their ability to stabilize the natural red color and inhibit microbial build-up throughout. storage (42). Mackerel fillets with sunflower oil nanoemulsions were taught to optimize appearance, texture and odor, which lengthens its effective history (28).

Thyme oil nanoemulsions were shown to improve the acceptability and sensory attributes of beef patties by preserving oxymyoglobin content and redness throughout storage (43). Generally, such studies suggest that the binding of nanoemulsions in foods for muscles can improve, or at least not negatively damage, their sensory and physicochemical characteristics. However, this may be dependent on the compatibility of the particular bioactive substances used with the particular product. For example, curcumin will introduce a yellow-orange color to products, while several essential oils have a distinctive flavor (such as thyme, cloves or lemon). Therefore, it could be essential to optimize the supply system used for the food product that is being fortified.

The important oil binding as an antimicrobial in conventional food coatings to maintain freshly cut fruits. and vegetables show serious problems thanks to their deep flavor and potential toxicity at high doses (44).

On the other hand, Radi et al. (2018) (45) observed higher scores in the categorization of sensory attributes once the orange slices were coated with nanoemulsion containing 1% substantial orange peel oil compared to the uncoated sample and the sample coated with microemulsion containing 0.5% substantial oil. Kim et al. (2014) (34) reported that the concentration of lemongrass oil in nanoemulsion did not harm the flavor of the grape due to the nanotechnological solution used for the production of nanoemulsion-based coatings where small doses of functional compounds are needed. In an existing analysis by Robledo et al. (2018) (46), the eatable coating with thymol nanoemulsion represented the best compromise to mask deep odor, low water solubility, high volatility, and decreased antimicrobial activity with thymol epoch. The flavor and aroma of the coated strawberries were initially impaired, even though their sensory appreciation improved from the fifth day of storage and showed similar scores to the controls, with a better aroma score on the 12th day of storage.

4. Conclusiones

Nanoemulsions continue to be explored as management systems for hydrophobic bioactive substances, such as nutrients, nutraceuticals, antimicrobials and antioxidants, in order to improve the stability, quality, nutritional profile and effective life of foods. Previous studies have shown that nanoemulsions have the possibility of improving the characteristics of meat products, fruits and vegetables. Many of the useful effects of nanoemulsions remain associated with the tiny size and large area of the droplet. In addition, it is feasible to integrate a variety of bioactives in a single supply system, such as hydrophobic, hydrophilic and amphiphilic, than the possibility of increasing their potency through additive or synergistic effects. These nanoemulsions give us different application possibilities in meat products.
The development of food-grade nanoemulsion capable of encapsulating and improving the functionality of certain types of active components is an obvious interest for a new generation of products. Antimicrobials, antioxidants and texture enhancers from natural sources are the potential choice for chemical additives, which represents a promising plan to provide safe food for the consumer.

The results of current studies point to the potential advantages of using nanoemulsion-based coatings formulated with natural active compounds on emulsion-based foods to improve the quality, stability, and effective shelf life of freshly cut fruits and vegetables. However, most of the studies discussed in this review were conducted at the laboratory scale. Therefore, more inquiries on a commercial scale are required to provide more realistic information using nanoemulsion-based coatings on meats, fruits and vegetables. In addition, more extensive investigation of the impact of such coatings on the sensory attributes of products is required. Despite these restrictions, the food industries are looking for a technology so creative that it can be used in a wide spectrum of foods that adds cost to their products, maintaining their quality and prolonging the effective life.

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