6.3.3 Liposomes

Liposomes are microscopic spherical vesicles containing at least one lipid bilayer, and can encapsulate both hydrophilic and hydrophobic materials. With industrial application in mind, a group of researchers designed liposomal formulations based on soy phosphatidylcholine, a natural lipid containing essential fatty acids like linoleic and linolenic acids. Stearic acid and calcium stearate were used to stabilize the liposomal formulation containing omega-3 and omega-6 fatty acids and vitamin E. Along with rheological properties, oxidative and thermal stability were also studied and a sensory evaluation was conducted in commercial chocolate milk. The results report the high encapsulation efficiency of folic acid and stable vitamin E after pasteurization, and conclude that the developed liposomal formulations containing bioactive compounds are suitable for food industry applications.[27] A highly disordered lipid nanomatrix containing fish oil enriched with omega-3 fatty acids that can protect and accommodate bioactive compounds was fabricated.[102] Effective encapsulation and delivery of lutein, a lipophilic bioactive pigment, was studied using this lipid nanocarrier. The nanoparticles were below 200 nm, and had high lutein entrapment efficiency and high antioxidant activity. Along with improving the solubility and stability of lutein, the presence of fish oil in the liposome increased the antioxidant capacity. Such nanolipid formulations could be successfully incorporated into food systems with enhanced nutraceutical activity.[102] The effect of nanoliposomse containing curcumin on the aggregation of amyloid fibrils associated with Alzheimer's disease was studied. Other liposomes associated with phosphatidic acid, cardiolipin and GM1 ganglioside were also compared with the anti-amyloid activity of curcumin. Nanoliposomes containing curcumin were prepared by three different approaches and the liposomes prepared by click chemistry showed the best results in inhibiting amyloid aggregation.[103] Hesperetin is a flavanone found in citrus fruits with anticancerous activity. By encapsulating in a lipid carrier, a nanoformulation of hesperetin was developed for fortifying functional foods. Nanolipid carriers have some limitations, such as rapid aggregation and burst release. The authors overcame these limitations by coating the hesperetin-loaded lipid nanostructure with various biopolymers, such as chitosan, alginate and methoxypectin, resulting in better release kinetics and higher stability. Additionally, the sensory qualities, such as taste, color and homogeneity, were also improved when tested in hesperetin-fortified milk. The authors hope that this formulation technology can be used for colon delivery of bioactive materials.[104]

6.3.4 Other Nanoformulation Strategies: Nanodisks, Nanogels, Nanofibers *etc.*

Electrospinning is a versatile method used to create nanofibers, where polymeric solutions under high electric force are spun into nanofibers. With unique physicochemical properties, electrospun nanofibers are used in