ABSTRACT

A healthy diet helps prevent malnutrition and non-communicable diseases (NCD). Cardiovascular diseases (CVD) are the major NCD causing maximum deaths worldwide. Edible oils play an important role in the causation, treatment, and prevention of CVD by regulating cholesterol levels. According to the American Heart Association (AHA), healthy cooking oil must satisfy the balance between monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA) (MUFA/PUFA= 1 to 1.5) and ω-6/ω-3 (1 to 4). Blending of different edible vegetable oils gives greater flexibility to satisfy nutritional requirements. In this study, three edible oils, *viz.* rice bran (RBO), flaxseed (FO), and peanut (PO), are selected for blending. The optimized oil blend (OB) with the highest oxidative stability comprises 72.5 % RBO, 20 % PO and 7.5 % FO. The OB had well-adjusted ratios of fatty acids, i.e., MUFA/PUFA= 1.1 and ω6/ ω3 = 2.7. The OB had a shelf-life of 239 days at 30 °C. The onset temperature (T_{onset}) of thermal degradation of optimized OB was noted as 209.21 °C. Poor bioavailability is one of the prime limitations in the absorption of vitamins after oral intake. PUFA-rich lipids have been explored in a multi-vitamin delivery system (liposomes) to offer better stability during severe processing conditions and enhance nutrient absorption. A computational study was carried out prior to the experiment to investigate the effect of temperature (40, 50, and 60 °C) on the melting of lipid bilayer containing soy lecithin. The average area per lipid (APL) and diffusivity coefficient D[mem] for all the bilayer combinations varied from 0.395 – 0.502 nm^2, 0.0405 – 0.1168 × 10^{-5} cm^2/s, respectively for gel-ripple-liquid phase. At 60 °C, 30 % oil blend with 5 % lecithin and 30 % oil blend with 10 % lecithin, provided the most mobility. Differential scanning calorimetry thermogram displayed the phase transition of soy lecithin at 59.87 °C. Experimental and computational studies on binding affinity revealed that hydrophobic vitamins had a better affinity and stronger interactions with the lipid bilayer membranes than hydrophilic vitamins. To enhance the entrapment of vitamins without compromising the liposome structure, freeze-drying of double emulsion in the presence of trehalose was adopted. The optimal liposome formulation and processing condition were reported as MPI 34 %, trehalose 20 %, lecithin 10 %, and 5 min ultrasonication time. The liposome particles of the single emulsion were giant-sized and unstable (size= 204 nm, zeta potential = -20.33 mV), but after ultrasonication, the large liposome particles were disrupted into smaller spherical ones (size = 172 nm, zeta potential = -28.50 mV). The dried liposome powders were more porous but irregular in shape. The reconstituted emulsion exhibited shrunk and aggregated particle morphology with a smaller size (size = 148 nm, zeta potential = -27.33 mV). The trehalose used as a cryoprotectant effectively increased the emulsion's transition temperature from 100 to 150 °C. The single emulsions were unstable at 25 and 55 °C storage temperatures, while double emulsions were stable for 22 days @ 55 °C and 36 days @ 25 °C. Biscuits made from liposomes containing encapsulated oil and vitamins provided a crispier texture with fewer surface cracks. During sequential in-vitro digestion, a sustained release of vitamins was observed in biscuits containing liposomes. The cost estimated for the developed fortified biscuits was comparable to the similar types of biscuits available in the market.

Keywords: Edible oil; Blending; Liposomes; Multi-vitamins; Computational studies; Freeze drying; Fortified biscuits; In vitro-studies