## Abstract

In this study, natural polymeric biofilms loaded with nanoemulsions of clove essential oil (CEO) were prepared as antibacterial agents for food packaging applications. The CEO nanoemulsions were prepared through ultrasonication, using whey protein isolate (WPI) as a natural emulsifier. The optimization parameters involved 2.5% WPI, 1:1 ratio of CEO to sunflower oil, and 15-minute ultrasonication, gave nanoemulsions with high transmittance of 94.5, particle size of 162 ± 3.00 nm, and polydispersity index of 1.16. Subsequently, films were prepared using a solution casting technique, incorporating wheat starch, carboxy methyl cellulose (CMC), and a blend of both, along with CEO nanoemulsion and glycerol as a plasticizer. Film optimization was based on polysaccharide concentration, glycerol content, and CEO nanoemulsion concentration. The optimal food packaging film was achieved with a blend of 5% wheat starch and 20% CMC (w/w wheat starch), containing 30% glycerol and 15% CEO nanoemulsion. The film had a thickness of 0.119 mm, UV transmittance of 29%, water solubility of 16.98%, a moisture content value of 9.12%, and exhibited significant antibacterial activity against *Staphylococcus aureus* and *Escherichia coli*. To evaluate practical applications, the optimized film, film without CEO nanoemulsion, and polyvinyl chloride wrap were employed to wrap raw meat pieces stored at 4 °C for 15 days. The meat wrapped in the optimized blend films showed the least change in pH, lower weight loss percentage, and the lowest total bacterial count after the 15-day storage period. . Therefore, CEO encapsulated in nanoemulsions incorporated with polymeric biofilms based on a mixture of wheat starch and CMC have the potential to be employed as bioactive edible food packaging materials in substitute of synthetic plastic packaging.