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The increased environmental pollution has led to finding sustainable solutions for non-renewable plastic-based food packaging materials. Thus, the use of biomaterial-based packaging material has become an immense trend. This work aims at developing an antimicrobial biodegradable chitosan-alginate bio-nano composite film with TiO_2 nanoparticle (NPs) for food packaging applications. The film was developed by a solution casting method. The chemical, mechanical, thermal, barrier, antimicrobial, and biodegradable properties of the packaging films were evaluated. Packaging studies were performed for 15 days for cherry tomatoes. The designed packaging material had enhanced the mechanical properties with a significantly ($p < 0.05$) higher tensile strength of 15.76 folds and 2 fold higher elongation at break. The UV barrier properties increased by 88.6%, while the film transparency decreased by 87.23%. Molecular interaction of N-H covalent bonds was observed between alginate and chitosan together with TiO_2 NPs. The developed bio-nano composite film showed antimicrobial activity against foodborne pathogens *E. coli*, *S. aureus*, *S. typhi*, and *L. monocytogene* with a log reduction of 7.08, 7.28, 6.04 & 6.02 log CFU/ml respectively at 24 hours incubation period. The film was completely biodegraded and a weight loss of 89.06% was observed in bio-nanocomposite film during the 3 months. Shelf-life estimation of cherry tomato using developed packaging films showed an increase in the shelf-life up to 8 days with stable pH, total soluble solids, and weight with no bacterial growth when packaged with prepared film. Owing to their improved mechanical, UV barrier, antibacterial, and biodegradability, the prepared active bio-nano composite packaging films could be considered a potential candidate for fruit packaging.