Abstract

High Performance Liquid Chromatography (HPLC) is widely applied in pharmaceutical, food, and clinical laboratories for quantifying fat-soluble vitamins (A, D, and E). Advances in column technology, particularly particle sizes below the conventional 5 µm such as 3.5 µm, promise faster analysis and higher sensitivity but raise questions about solvent consumption, run time reduction, cost efficiency, and regulatory acceptance. The problem addressed in this study is how laboratories can balance throughput and cost savings with compliance to chromatographic equivalency guidelines.

The purpose of this research is to evaluate whether 3.5 µm columns can deliver measurable analytical, economic, and sustainability benefits while meeting regulatory standards. Comparative Methodology: Comparative HPLC experiments were conducted using 3.5 µm and 5 µm columns, supported by economic modelling of solvent and labour savings, and enriched by stakeholder feedback through workshops and unstructured observation.

Results show that the 3.5 µm column significantly reduced run time and solvent consumption while maintaining system suitability criteria. Financial modelling demonstrated positive ROI, payback period, and Net Present Value (NPV), highlighting economic feasibility. Combined empirical evidence and stakeholder perspectives support a staged adoption strategy with targeted pilots, vendor support, and regulatory engagement to optimize analytical performance, economic outcomes, and sustainable laboratory operations (He et al., 2026; Siddique, 2024).

Keywords: HPLC, fat-soluble vitamins, 3.5 µm column, solvent consumption, run time reduction, ROI, payback period, Net Present Value (NPV), stakeholder feedback, adoption strategy