

Method	Primary Target	Analytical Role	Typical Setting	Sensitivity (LOD/LOQ)	Turnaround Time	Cost	Validation Status	Key Advantages	Key Limitations
ELISA	Allergen-specific intact proteins (epitopes)	Routine quantitative /qualitative testing; HACCP verification; regulatory compliance support	QA/QC laboratories	High sensitivity (ppb-low ppm range depending on matrix)	Hours to ~1 day	Moderate	Widely validated (AOAC / ISO / commercial kit validations)	High sensitivity; quantitative capability; well-established regulatory acceptance; broad	Epitope degradation in processed foods; cross-reactivity; matrix effects; single-target per assay
Lateral Flow Devices (LFDs)	Allergen-specific proteins	Rapid on-site screening; environmental swabbing; post-clean verification	Production floor / in-plant	Moderate (typically higher LOD than ELISA; variable by kit)	Minutes	Low per test	Partially validated (kit-dependent; often aligned to ELISA reference methods)	Very rapid; simple operation; no instrumentation; real-time decision support	Qualitative or semi-quantitative only; lower sensitivity; operator interpretation variability; matrix
LC-MS/MS	Peptide markers from allergenic proteins	Confirmatory analysis; high-specificity quantitation; method validation support	Specialized analytical laboratories	Very high analytical specificity; LOD typically low ppm to sub-ppm depending on matrix and method	Days	High	Strong validation in targeted proteomics frameworks (AOAC / ISO / peer-reviewed methods)	High specificity; multiplex capability; robust in processed foods; confirmatory strength	Expensive instrumentation; complex sample prep; matrix effects; not suitable for routine in-plant screening
PCR / RT-qPCR	DNA from allergenic source organisms	Ingredient verification; traceability; contamination investigation	Molecular biology laboratories	Very high sensitivity (trace DNA detection; not directly comparable to protein-based LOD)	Hours to 1-2 days	Moderate High	Widely validated for species detection; limited allergen-specific regulatory use	High sensitivity; robust in processed foods; multiplex DNA detection possible	Indirect allergen relevance; detects DNA not protein; cannot quantify allergen dose; potential regulatory
Protein Swab Tests	Total protein (non-specific)	Cleaning verification; sanitation effectiveness monitoring	In-plant hygiene monitoring	Not allergen-specific (no defined allergen LOD)	Minutes	Low	Operational validation only (cleaning verification studies)	Fast; inexpensive; simple; useful for CIP verification	Non-specific; cannot identify allergens; limited risk interpretation value
ATP Swab Tests	ATP (general biological residue)	General hygiene monitoring; cleaning trend verification	In-plant sanitation monitoring	Not allergen-specific	Seconds to minutes	Very low	Operational hygiene indicator (not allergen validated)	Extremely rapid; simple; useful for hygiene trend tracking	Not allergen-specific; detects all organic residue; weak correlation with allergen