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## Food Quality Control for Sensitive Consumer Segments: Challenges and Approaches in Child Nutrition

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### Abstract

Children are a highly vulnerable consumer group because rapid growth, immature immune and metabolic systems, and high food intake relative to body weight increase sensitivity to foodborne hazards. This review synthesizes recent literature and regulatory documents on quality control for infant and child nutrition, focusing on microbiological hazards, chemical contaminants, allergens, nutritional adequacy, analytical control methods and regulatory frameworks.

Keywords: allergen detection; biosensors; foodborne pathogens; nutritional profiling; regulatory harmonization; vulnerable populations

### • Introduction

- Infants and young children depend on commercial formula, cereal-based and complementary foods during critical windows of growth, immunity and neurodevelopment.
- Their lower tolerance to pathogens, contaminants and nutritional imbalances requires stricter quality criteria than those applied to adult foods.
- Main control challenges include Salmonella spp. and Cronobacter sakazakii, heavy metals, mycotoxins, pesticide residues, allergens and inaccurate nutrient declarations.
- Regulatory divergence between the EU, US, China and Codex creates uneven protection and substantial compliance burdens for global manufacturers.

### Material and method

The paper was developed as a narrative review of peer-reviewed studies, analytical guidelines and official regulatory documents relevant to infant and child food quality control.

#### Literature sources

- Databases searched: Google Scholar, PubMed and ScienceDirect.
- Main keywords: infant food, baby food, infant formula, food safety, Cronobacter sakazakii, Salmonella, heavy metals, mycotoxins, allergens, ICP-MS, LC-MS/MS, biosensors and blockchain traceability.

#### Selection criteria

- Included: primary data, regulatory analysis and methodological evaluations linked to microbiological safety, chemical contamination, nutrient composition, allergen control or comparative regulation.
- Excluded: sources with only general food safety data and no specific relevance to infant or young-child nutrition.
- Final synthesis retained 49 references, mainly from 2015–2025, with older foundational studies included where necessary.

### • Results and discussions

#### 1. Hazard profile in child-oriented foods

- Microbiological risks are dominated by Salmonella spp. and Cronobacter sakazakii, especially in powdered infant formula and cereal-based products.
- Chemical concerns include lead, cadmium, inorganic arsenic, mercury, mycotoxins and pesticide residues; rice-, cereal- and fish-based products require particular surveillance.
- Allergen management must combine accurate declaration with prevention of cross-contact, but precautionary allergen labeling remains inconsistently applied.

#### 2. Regulatory and nutritional control gaps

- EU rules are more precautionary, with strict contaminant limits, broad allergen labeling and mandatory DHA in infant formula.
- China strengthened registration and formulation control after the 2008 melamine crisis, while the US model relies more strongly on manufacturer notification and preventive controls.
- Labeling studies show that declared and measured nutrient values often diverge, which is critical when diets are planned for sensitive developmental stages.

#### 3. Analytical approaches with near-term impact

- ICP-MS is central for ultra-trace heavy metal detection; LC-MS/MS supports simultaneous mycotoxin and contaminant screening.
- ELISA and PCR remain key for allergen and pathogen testing, but processed matrices can reduce reliability and require validated workflows.
- NIR spectroscopy, biosensors and blockchain traceability can strengthen rapid monitoring, at-line quality control and supply-chain transparency.

### Conclusions

- Food quality in child nutrition must integrate hazard elimination with nutritional adequacy and clear risk communication.
- No single method or discipline is sufficient; effective protection requires food technology, pediatric nutrition, toxicology, regulation and consumer education.
- The most important future directions are child-specific risk thresholds, harmonized contaminant and allergen limits, and wider adoption of rapid detection and traceability technologies.

### Quality-control priority matrix for child nutrition

Quality domain	Main risk for children	Current control focus	Emerging improvement
Microbiology	Salmonella spp. and Cronobacter sakazakii in dry infant foods	Zero-tolerance criteria; environmental monitoring; preventive controls	Rapid biosensors and LAMP/PCR screening
Chemical safety	Heavy metals, mycotoxins and pesticide residues in rice, cereal and fish matrices	Low maximum limits; multi-residue surveillance; supplier qualification	ICP-MS/LC-MS-MS workflows plus traceability systems
Nutrition and labeling	Mismatch between declared and measured nutrient content	Compositional standards; label verification; tolerance limits	Nutritional profiling integrated with safety assessment
Allergen management	Cross-contact and inconsistent precautionary allergen labeling	Mandatory allergen declaration; hygiene and segregation plans	Risk-based thresholds and harmonized PAL decisions