A DECISION-SUPPORT MODEL FOR FOOD PRODUCTION-CHAIN RISK RANKING USING AHP-TOPSIS

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Abstract. Hazards along a food production chain are not distributed evenly: raw-material reception, processing, storage and transportation each carry a distinct hazard profile and a distinct capacity for control. This thesis proposes a risk-ranking framework combining the Analytic Hierarchy Process (AHP) and TOPSIS with a criteria set derived clause-by-clause from ISO 22000 and ISO/IEC 17025. Seven standards-based criteria were weighted by AHP (CR = 0.011) and applied through TOPSIS to rank four production-chain stages by a risk-priority coefficient. Storage and transportation emerged as the highest-priority stages for intervention, while processing ranked lowest once control-measure effectiveness and measurement reliability were accounted for; a sensitivity analysis confirmed the ranking is stable under ±10% weight perturbation.

Keywords: food safety risk assessment, AHP-TOPSIS, ISO 22000, ISO/IEC 17025, multicriteria decision making, production-chain hazard ranking.

Introduction

Food safety incidents rarely originate at a single, isolated point: a contaminant introduced during processing behaves differently, and demands a different control response, than a temperature excursion during storage or cross-contamination during transport. HACCP programmes and ISO 22000 give organizations a structured way to identify such hazards, but remain qualitative frameworks-they specify what must be analyzed, not how competing hazards across different stages should be ranked when inspection and upgrade resources are limited. A second, often underestimated source of risk is epistemic rather than physical: a food safety system is only as trustworthy as the laboratory data feeding it, which is precisely the domain ISO/IEC 17025 regulates. A stage can appear low-risk simply because its monitoring is imprecise, not because the underlying hazard is small-so combining a food-safety-management standard with a laboratory-competence standard in one ranking exercise guards against a false sense of safety.

Seven criteria were derived from clauses of ISO 22000:2018 and ISO/IEC 17025:2017: microbiological, chemical and physical hazard likelihood (C1–C3, clause 8.5), control-measure effectiveness (C4, clause 8.5.4), measurement and monitoring reliability (C5, ISO/IEC 17025 clause 7.7), traceability and documentation (C6, clause 8.3), and severity of consequence (C7, Codex Alimentarius CAC/RCP 1-1969). Local weights were obtained from the principal eigenvector w of the pairwise comparison matrix A, satisfying $Aw = \lambda_{max} \cdot w$; with $n = 7$, $\lambda_{max} = 7.085$ gave a consistency index $CI = (\lambda_{max} - n)/(n - 1) = 0.014$ and, against Saaty's random index $RI = 1.32$, a consistency ratio $CR = 0.011$-comfortably under the 0.10 acceptability threshold. Microbiological hazard likelihood (C1, weight 0.231) and control-measure effectiveness (C4, weight 0.223) dominated the weight structure, together accounting for over 45% of total influence, while measurement and monitoring reliability (C5, weight 0.132) ranked fourth.

Four canonical stages-raw material reception (A1), processing (A2), storage (A3), and transportation/distribution (A4)-were ranked by TOPSIS. The decision matrix was vector-normalized as $r_{ij} = x_{ij}/\sqrt{(\Sigma x_{ij}^2)}$ and weighted as $v_{ij} = w_j \cdot r_{ij}$; the positive- and negative-ideal solutions (PIS, NIS) were built from the best and worst observed values per criterion, hazard criteria (C1–C3) treated as cost-type and control/reliability criteria (C4–C7) as benefit-type. Euclidean distances d_i^+ and d_i^- to the PIS and NIS yielded the risk-priority coefficient $R_i = d_i^+/(d_i^+ + d_i^-)$, the complement of the classical closeness coefficient C_i. Storage (A3, $R_i = 0.681$) and transportation (A4, $R_i = 0.636$) ranked as the two highest-priority stages, ahead of raw-material reception (A1, $R_i = 0.461$) and processing (A2, $R_i = 0.319$)-a result that diverges from a pure hazard-likelihood ordering because control-measure effectiveness and measurement reliability are concentrated at processing under ISO 22000. A one-way sensitivity analysis, perturbing the C4 weight by ±10%, preserved the rank order A3 > A4 > A1 > A2 at every step, with the top-ranked stage's R_i varying only between 0.664 and 0.696.

Conclusion. The proposed AHP-TOPSIS framework, with criteria traced clause-by-clause to ISO 22000 and ISO/IEC 17025, ranked storage and transportation as the highest-priority stages for risk-mitigation investment, a ranking shown to be robust under moderate

weight perturbation. Because the criteria structure is standards-based and generic with respect to food category, it can be re-parameterized for a specific product line without altering its architecture, and is intended to extend into a broader Standardized Food Quality Index. Future work will validate the baseline weighting against an independently sampled expert panel and recorded nonconformity data from operating facilities.

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