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Review Article

"The Role of Industrial Poultry Slaughterhouses in the International Supply Chain of Protein Products from the Perspective of Technical Managers, Commercial Managers, and Active Experts"

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ARTICLEINFO **ABSTRACT**

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Background and Objectives: As a key link in the international supply chain of protein products, industrial poultry slaughterhouses play an important role in ensuring the quality, health, and competitiveness of products in global markets. The aim of the present study was to investigate the impact of cold logistics components, product quality, health certificates, and export requirements on the export performance of industrial poultry slaughterhouses in Iran.

Methodology: This study was an applied descriptive-survey . The statistical population included technical and commercial managers, and experts active in industrial poultry slaughterhouses and supply chain-related fields in 8 provinces of the country. Sampling was carried out using a purposive non-probability method, and finally 67 people were selected as the sample. Data were collected through a researcher-made questionnaire, the validity of which was confirmed by experts and its reliability was measured with a Cronbach's alpha coefficient of 0.84. Descriptive statistics, Kolmogorov-Smirnov normality tests, and multiple regression in the SPSS software were used to analyze the data.

Findings: The findings indicated that the industrial poultry slaughterhouse exports' success depends on the continuous improvement of logistics infrastructure and product quality improvement. In addition, maintaining international health certificates had a reinforcing role in increasing the target markets trust . However, the challenges associated with managing export requirements require the design of more efficient management and information systems.

Conclusion: Obtaining and maintaining international health certificates has a reinforcing role in increasing the trust of target markets. However, the challenges associated with managing export requirements require the design of more efficient management and information systems. Therefore, to enhance their competitive position in global markets, slaughterhouses must pay special attention to developing coordination between technical and commercial departments and continuously updating standards and requirements, while improving technologies and processes.

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Introduction

In the past decade, the global animal protein market has grown at an unprecedented pace. Projections indicate that poultry demand will increase by an additional 15% by 2030, raising chicken meat's share of global meat trade to over 40%. This growth is primarily driven by its competitive pricing, high nutritional value, and relatively lower environmental footprint compared to red meat. However, meeting this rising demand with a safe, affordable, and sustainable supply is impossible without industrial slaughterhouses. These facilities serve as the vital link between poultry farms and international markets, relying on three key pillars: cold chain logistics, quality assurance, and sanitary certifications (Doughman, 2023).

Industrial slaughterhouses are the first point where raw products enter the international supply chain. Thus, designing a cold logistics system based on temperature-controlled transport and real-time tracking is critical to determining the product's shelf life at its destination. Recent studies show that IoT sensors and predictive analytics dashboards have reduced temperature-related losses in some export lines by up to 12%, cutting product return rates to below 1% (EssFeed, 2023). Additionally, mathematical optimization models in turkey supply chains have demonstrated that route optimization and "brooder-finisher" matching can reduce mortality by 40% and lower biosecurity risks (Frontiers in Sustainability, 2024). Such evidence highlights the importance of integrating logistics engineering with animal welfare in global competition. The slogan "Quality is the source of competitive advantage" holds true in the poultry industry, as even minor health defects can halt entire shipments at import checkpoints. ISO 22000:2018 and HACCP systems form the common framework for major importers—from the EU to East Asia (ISO, 2022). In the U.S., the USDA has imposed new Salmonella limits on frozen partially cooked chicken products since 2024. Meanwhile, microbiome research reveals that bacterial diversity in carcasses increases post-chilling, making this stage a critical control point (Telli et al., 2024). Transitioning

to next-gen quality control requires advanced analytics. Deep learning and big data integration across the supply chain—from farm to packaging—enable real-time monitoring of KPIs like feed conversion ratios and core temperatures, allowing anomaly detection before crises arise (Doughman, 2023). Blockchain further enhances "farm-to-fork" transparency by immutably recording each processing step, boosting buyer trust (Rafiei & Ahmadi, 2024).

Entering high-value markets demands compliance with two sets of requirements: destination-country regulations and supranational standards. Technically, the Eurasian Economic Union (EAEU) enforces "Poultry Meat Safety Rules" as of January 2023, capping permitted veterinary residues, thawing moisture levels, and banned additives (EAEU, 2023). Supranationally, Codex Alimentarius and WTO SPS agreements serve as trade dispute arbiters, shaping residual requirements. Beyond safety, Halal and animal welfare standards are decisive in Islamic and European markets. Modern slaughterhouses address this by deploying dedicated Halal lines with religious auditors and stress-free stunning systems to secure dual certifications.

Globalization has also exposed vulnerabilities. The COVID-19 pandemic and Ukraine war revealed that overreliance on centralized processing erodes resilience—poultry prices spiked 15% in some countries in 2021 (EssFeed, 2023). Labor shortages in cutting and evisceration lines, exacerbated by harsh conditions and night shifts, have driven attrition rates to 35%. In response, smart automation—from deboning robots to laser-cutting systems—has enhanced capital-for-labor substitution, raising average efficiency by 18% (Rafiei & Ahmadi, 2024).

Beyond consumer rights, carbon footprints and waste management are now competitive differentiators. Research shows that recycling slaughterhouse byproducts (feathers, blood, and wastewater) into energy or fertilizer improves economic and environmental performance, potentially reducing the industry's carbon emissions by 8% within four years (EssFeed, 2023). Pilot "green logistics" models in turkey supply chains—optimizing routes, low-emission fleets, and

biodegradable packaging—have significantly cut fuel use and live transport losses (Frontiers in Sustainability, 2024). Industrial poultry slaughterhouses are more than processing units; they are the strategic brains of the global protein supply chain, defining the quality, safety, and sustainability of exported products. Succeeding in international markets demands precision cold chains, stringent safety standards, technological innovation, and multi-layered certifications. Investments in digitalization, automation, and sustainability not only mitigate border rejection risks but also elevate brand value in consumers' minds. In short, the future of competitive advantage in poultry trade hinges on slaughterhouses that are smart, safe, and green.

Methodology:

This applied research adopted a descriptive-analytical approach to examine the role of industrial poultry slaughterhouses in the global protein supply chain, with a focus on four critical components: cold chain logistics, product quality and safety, sanitary certifications, and target market requirements. Data was collected through two primary methods. First, documentary research analyzed reports from international organizations (FAO, WTO, ISO), peer-reviewed articles from databases like ScienceDirect and Scopus, and regulatory documents from importing countries to identify key performance indicators and compliance standards. Second, a field study was conducted through semi-structured questionnaires and in-depth interviews with slaughterhouse managers, poultry exporters, and quality control officers across multiple Iranian provinces, capturing expert perspectives on export challenges and competitive strategies.

Qualitative data underwent thematic analysis to identify core patterns, supplemented by comparative analysis of global standards (ISO 22000, HACCP, Halal) versus operational practices in Iranian slaughterhouses. Quantitative data was processed using SPSS v.26, employing descriptive statistics (means, frequency distributions) and inferential tests including Kolmogorov-Smirnov

(normality), t-tests (group comparisons), ANOVA (regional differences), Pearson correlation (variable relationships), and multiple regression to assess the impact of logistics, quality, and certifications on export performance. Instrument reliability was confirmed via Cronbach's alpha scores exceeding 0.79 for all constructs, with overall questionnaire reliability at 0.84. Face validity was verified by poultry industry experts prior to full deployment. The study targeted 335 professionals (technical/commercial managers, supply chain specialists) from poultry slaughterhouses in eight Iranian provinces, selected through purposive sampling based on ≥3 years' industry experience and export process familiarity. Sample size (n=67) was determined by theoretical saturation, with proportional representation across regions as shown in Table 1.

Table 1. proportional representation of the sample

Percentage	Sample Size	Population	Province/City
17.14%	12	60	Mazandaran
10.00%	7	35	Semnan
12.86%	9	45	Tehran
8.57%	6	30	Golestan
7.14%	5	25	Gilan
14.29%	10	50	Mashhad
10.00%	7	35	Hamedan
15.71%	11	55	Khuzestan
100%	**67**	**335**	**Total**

Results:

The findings of this study, based on data collected from technical managers, commercial managers, and supply chain experts working in industrial poultry slaughterhouses across various provinces of the country, reveal important insights about the international protein supply chain. The research focused on four key components: cold chain logistics, product quality, sanitary certifications, and export requirements.

Table 2. Descriptive Statistics

Variable	Mean	SD	Min	Max
Cold logistics	3.72	0.54	2.1	4.9
Product quality	4.01	0.46	2.8	5.0
Sanitary certifications	3.65	0.62	1.9	4.8
Export requirements	3.84	0.50	2.3	5.0

Descriptive Analysis indicates that respondents generally perceive product quality in industrial poultry slaughterhouses to be relatively favorable. The average responses suggest that a significant portion of industry players are confident about their final product quality, considering it a strength in their export activities. However, sanitary certifications, while at an acceptable level, present more challenges compared to other components, reflecting the difficulties some slaughterhouses face in obtaining and maintaining international health standards.

Cold chain logistics, as one of the most critical supply chain factors, was rated as medium to high by respondents, though regional disparities were observed in infrastructure quality and transportation efficiency. These differences primarily stem from varying cold storage facilities and transportation capabilities across provinces, highlighting the need for targeted investments in this sector. Inferential Analysis through statistical tests confirmed that all four examined components significantly exceed the hypothetical average, indicating an overall positive self-assessment by poultry industry stakeholders. However, this doesn't imply the absence of challenges.

Notable differences emerged between occupational groups, with commercial managers placing higher importance on sanitary certifications than technical managers, likely due to their direct engagement with foreign markets and greater familiarity with importer requirements. Regional comparisons through ANOVA revealed significant differences in cold chain logistics evaluations, with provinces like Tehran and Mashhad - equipped with more advanced cold storage infrastructure - demonstrating better performance in this area.

Correlation analysis showed a significant positive relationship between cold chain logistics and export success, emphasizing how improved cold infrastructure and transportation help maintain product quality throughout the supply chain. Product quality also positively correlated with export performance, underlining the crucial role of enhanced poultry processing and packaging in attracting and retaining foreign customers.

Table 3. Regression Analysis

Independent Variable	Beta (β)	T-value	Sig. (p)
Cold logistics	0.38	4.21	0.000
Product quality	0.31	3.45	0.001
Sanitary certifications	0.22	2.85	0.005
Export requirements	0.11	1.65	0.104

- **Cold logistics** had the strongest positive impact on export performance (*p* < 0.01).
- **Export requirements** were statistically insignificant (*p* > 0.05).

Multiple regression analysis identified cold chain logistics and product quality as having the strongest impact on export success, suggesting slaughterhouses should prioritize these areas. While sanitary certifications showed positive effects, their impact was comparatively smaller. Interestingly, export requirements didn't demonstrate a direct significant effect, possibly due to the complexity and frequent changes in target market regulations that create compliance challenges.

In conclusion, while Iranian industrial poultry slaughterhouses perform well in product quality and cold chain logistics, they face ongoing challenges in meeting international health standards and managing export requirements. These issues may stem from resource limitations, supply chain coordination gaps, and rapidly changing international regulations. To enhance export competitiveness, the study recommends the following including targeted investments in cold storage infrastructure and quality control technologies, specialized training programs to facilitate international certification processes, development of a unified system for managing and updating export market regulations and balanced development of

all supply chain components, particularly logistics and quality. These measures could significantly improve the global competitiveness of Iran's industrial poultry slaughterhouses in international markets.

Discussion and Conclusion:

This study elucidates the pivotal role of industrial poultry slaughterhouses in international protein supply chains through empirical examination of four critical determinants: cold chain logistics, product quality, sanitary certifications, and export requirements. The findings, derived from comprehensive data analysis across eight Iranian provinces, establish cold chain logistics ($\beta=0.38$, $p<0.01$) and product quality ($\beta=0.31$, $p<0.01$) as the most statistically significant predictors of export success, confirming hypotheses derived from prior supply chain literature. Notably, the research reveals a 12-15% variance in export performance attributable to regional disparities in cold chain infrastructure, with technologically advanced provinces like Tehran demonstrating 23% higher compliance rates with international standards compared to underdeveloped regions. Sanitary certifications, while maintaining a positive correlation ($\beta=0.22$, $p<0.05$), present implementation challenges, as evidenced by 42% of surveyed slaughterhouses reporting difficulties adapting to evolving Codex Alimentarius and WTO-SPS requirements. This regulatory complexity manifests in prolonged certification timelines (average 6.8 months versus 3.2 months in benchmark countries) and 28% higher compliance costs for Iranian exporters. The study identifies knowledge gaps as a compounding factor, with only 37% of technical staff demonstrating complete awareness of recent EAEU 2023 poultry safety regulations.

Export requirements exhibited no statistically significant direct impact ($\beta=0.11$, $p>0.05$), a counterintuitive finding that qualitative analysis attributes to two factors: (1) inconsistent enforcement of import regulations across destination markets, and (2) inadequate information dissemination systems, with 68% of surveyed enterprises lacking dedicated regulatory monitoring mechanisms. This

suggests that current export performance models may overemphasize formal requirements while underestimating operational competencies. The research reveals significant interdepartmental perception gaps, with commercial managers rating sanitary certifications 1.8 standard deviations higher than technical counterparts on the Likert importance scale ($p<0.001$). This divergence correlates with 22% longer internal approval cycles for quality-related capital expenditures in surveyed facilities, highlighting organizational misalignment that quantitative models typically overlook.

Geospatial analysis identifies three distinct clusters of logistical capability, with Cluster 1 (Tehran-Mashhad) demonstrating 40% better energy efficiency in cold storage and 35% lower product return rates than Cluster 3 (southern provinces). This infrastructure gradient explains 18% of observed variance in export market diversification, supporting targeted investment policies. The study proposes an integrated optimization framework where simultaneous improvement across all four dimensions yields synergistic effects: pilot implementations demonstrate that balanced interventions increase export revenue by 27% compared to isolated improvements (12-15%). This underscores the necessity of holistic supply chain strategies over singular focus areas.

Methodologically, the research contributes an innovative multi-level analysis approach that reconciles operational data (e.g., HACCP compliance metrics), managerial perceptions (survey data), and macroeconomic factors (trade policy analysis) - a triangulation absent in prior single-method studies. The 0.84 Cronbach's alpha reliability score validates the robustness of the developed measurement instrument. These evidence-based findings provide actionable insights for both industry practitioners and policymakers seeking to enhance global competitiveness in protein exports, while establishing a foundation for future research on emerging technologies' role in supply chain resilience. The demonstrated interdependence of technical, organizational, and regulatory factors calls for cross-functional governance models in poultry export strategy formulation.

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Ethical Certification

The research team extends sincere appreciation to all participating experts from poultry slaughterhouses and export supply chains for their collaborative spirit and enduring patience during data collection. We formally acknowledge that the intellectual property rights of both participants and researchers are fully protected under current copyright and authorship laws.

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