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Status, Challenges and Future Prospects of Fish Processing Technology in India

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ABSTRACT

Fish processing technology plays a vital role in enhancing shelf life, ensuring food safety, reducing post-harvest losses, and improving the economic utilization of fisheries resources. In India, rapid growth in fish production from both marine and inland sectors has increased the demand for efficient post-harvest handling, processing, and value addition systems. However, the highly perishable nature of fish, combined with tropical climatic conditions, inadequate cold chain infrastructure, microbial spoilage, and limited adoption of advanced processing technologies, continues to pose significant challenges to the sector. This review critically examines the current status of fish processing technology in India, with emphasis on processing infrastructure, post-harvest handling practices, quality management systems, and traditional as well as modern preservation techniques. Major constraints affecting the sector, including technological gaps, skill shortages, food safety concerns, regulatory complexities, and stress-induced quality deterioration during harvesting and handling, are discussed. The review further highlights emerging trends and future prospects, focusing on advanced and non-thermal processing technologies, value-added product development, sustainable utilization of processing by-products, and digitalization of fish processing value chains. The findings underscore the need for an integrated approach that combines technological innovation, stress mitigation strategies, capacity building, and policy support to strengthen fish processing systems in India. Such an approach can enhance product quality, minimize losses, improve market competitiveness, and contribute to the sustainable development of the fisheries sector.

KEYWORDS: Status, challenges and future prospects of fish processing technology in India

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1. INTRODUCTION

Fish and fishery products constitute an important component of global food systems owing to their high nutritional value and significant contribution to food and nutritional security. Fish is an excellent source of high-quality protein, essential amino acids, vitamins, minerals, and long-chain omega-3 polyunsaturated fatty acids, which are associated with numerous health benefits. As a result, fish consumption plays a crucial role in improving human nutrition and supporting sustainable food systems (Anonymous, 2020; Venugopal, 2006). Despite its nutritional importance, fish is one of the most perishable food commodities. The high moisture content, neutral pH, presence of autolytic enzymes, and rapid microbial proliferation accelerate spoilage immediately after harvest. In tropical countries such as India, high ambient temperatures further intensify biochemical and microbiological deterioration, resulting in substantial post-harvest losses if adequate preservation measures are not adopted (Huss, 1995; Gram and Dalgaard, 2002; Ghaly et al., 2010). Fish processing technology plays a vital role in preserving fish quality, extending shelf life, ensuring food safety, reducing post-harvest losses, and enhancing the economic value of fishery resources. Processing operations such as chilling, freezing, drying, smoking, canning, retort processing, and value addition enable the conversion of highly perishable raw material into stable, safe, and marketable products suitable for domestic consumption and international trade (Venugopal and Shahidi, 1995; Venugopal, 2006). India is one of the leading fish-producing countries in the world, supported by extensive marine fisheries resources and rapidly expanding aquaculture production. The fisheries sector contributes significantly to national income, employment generation, nutritional security, and foreign exchange earnings. The continued growth of aquaculture and seafood exports has increased the need for efficient post-harvest handling systems, modern processing technologies, quality assurance programs, and robust cold chain infrastructure to maintain product quality throughout the supply chain (Anonymous, 2022; Anonymous, 2023). Although fish production has increased considerably over the past decades, post-harvest losses remain a major challenge in many developing countries, including India. Inadequate icing facilities, poor handling practices, insufficient cold storage capacity, and interruptions in the cold chain often result in deterioration of product quality and reduction in market value. Such losses not only affect economic returns but also raise concerns regarding food safety and consumer confidence (Huss, 1995; Ghaly et al., 2010). Recent advances in fish processing technology have created opportunities to improve product quality, safety, and shelf life. Conventional preservation techniques are increasingly being supplemented by innovative approaches such as high-pressure processing, modified atmosphere packaging, cold plasma treatment, and other non-thermal technologies that minimize quality degradation while ensuring microbial safety (Rastogi et al., 2007; Misra et al., 2019). These emerging technologies are gaining attention because they help preserve the nutritional and sensory attributes of seafood products while meeting modern consumer expectations. In addition to processing innovations, digital technologies are increasingly transforming seafood supply chains. Blockchain-based traceability systems, sensor-enabled monitoring, and data-driven quality management tools are being explored to improve transparency, product authentication, and operational efficiency throughout the value chain (Ting et al., 2020). Such technological interventions are expected to strengthen quality assurance systems and facilitate compliance with increasingly stringent international food safety standards. Consumer preferences have also shifted towards convenient, nutritious, ready-to-cook, and ready-to-eat seafood products. This changing market demand has stimulated the development of value-added fish products and innovative seafood formulations that offer enhanced convenience and market appeal (Venugopal and Shahidi, 1995). Furthermore, growing emphasis on sustainability and circular bioeconomy principles has encouraged the utilization of fish processing by-products for the production of fish oils, protein hydrolysates, collagen, gelatin, and other high-value products, thereby reducing waste and improving resource utilization efficiency (Rustad et al., 2011; Roy et al., 2023). Considering the rapid technological developments, increasing quality requirements, and growing importance of sustainability in the fisheries sector, a comprehensive understanding of fish processing technology is essential for ensuring future growth and competitiveness. Therefore, the present review aims to examine the current status of fish processing technology in India, identify major challenges affecting the sector, and discuss emerging technologies and future prospects for sustainable development of the fish processing industry.

2. STATUS OF FISH PROCESSING TECHNOLOGY IN INDIA

2.1. Growth of the fish processing sector

The fish processing sector in India has expanded considerably over the past two decades, driven by rising fish production, increasing seafood exports, and changing domestic consumption patterns. India is one of the leading fish-producing nations globally, supported by rapid growth in aquaculture, particularly shrimp farming and freshwater fish culture. This expansion in primary production has necessitated parallel growth in post-harvest handling, cold chain development, and processing infrastructure to reduce losses and enhance value addition (Anonymous, 2022; Anonymous, 2023). Processing activities in India range from traditional preservation practices such as icing, drying, salting, and smoking to modern industrial operations including freezing, canning, retort pouch processing, and value-added seafood manufacturing. Traditional methods continue to play an important role in preserving fish in rural and coastal regions, while modern processing technologies have gained prominence in export-oriented industries (Bhalavey et al., 2025; Venugopal, 2006). Export processing units, particularly those handling shrimp and marine finfish, have adopted improved sanitation systems, mechanized handling facilities, and internationally recognized quality assurance programs to comply with stringent importing-country requirements (Anonymous, 2023). The implementation of Hazard Analysis and Critical Control Point (HACCP) systems, traceability mechanisms, and export inspection protocols has significantly strengthened India's competitiveness in international seafood markets. Despite this progress, the growth of fish processing infrastructure remains regionally uneven. Advanced processing facilities are concentrated mainly in coastal states such as Andhra Pradesh, Gujarat, Kerala, and Tamil Nadu, where marine fisheries and shrimp aquaculture are well developed. In contrast, many inland regions continue to depend on traditional preservation and marketing systems despite substantial freshwater fish production (Anonymous, 2022). This geographical imbalance limits opportunities for value addition of freshwater fish species and contributes to post-harvest losses. Therefore, strengthening inland cold chain networks, transportation facilities, and decentralized processing infrastructure is essential for achieving balanced growth of the fish processing sector in India.

2.2. Processing infrastructure and technologies

Freezing remains the backbone of India's fish processing industry. A well-developed network of ice plants, cold storages, freezing units, and refrigerated transportation systems supports both export and domestic seafood supply chains. Plate freezers, blast freezers, and Individual Quick Freezing (IQF) technologies are widely employed in export-oriented processing facilities to maintain product quality and comply with international market specifications (Venugopal, 2006; Anonymous, 2022). Rapid freezing minimizes the formation of large ice crystals within fish muscle, thereby preserving texture, flavor, nutritional quality, and overall product acceptability during storage. However, dependence on conventional freezing as the primary preservation strategy has certain limitations. Extended frozen storage may lead to lipid oxidation, protein denaturation, moisture loss, drip formation during thawing, and gradual deterioration of sensory characteristics, particularly in fatty fish species (Love, 1997; Sikorski and Kolakowska, 2002; Huss, 1995). The magnitude of these changes depends on storage temperature, duration, packaging conditions, and the effectiveness of cold chain management. Inadequate temperature control during transportation, storage, and retail distribution further contributes to quality deterioration and economic losses. Technological modernization beyond conventional freezing is gradually progressing in India's fish processing sector. Modified atmosphere packaging (MAP), vacuum packaging, retort pouch processing, and other advanced preservation technologies are increasingly being adopted to improve shelf life, maintain product quality, and enhance food safety (Sivertsvik et al., 2002; Parlapani et al., 2015). Modified atmosphere packaging reduces microbial growth and oxidative changes by altering the gaseous environment surrounding the product, while vacuum packaging restricts oxygen availability and delays spoilage reactions. Retort pouch processing has emerged as a promising technology for the production of ready-to-eat seafood products. By combining thermal sterilization with flexible multilayer packaging materials, retort processing achieves commercial sterility while preserving desirable sensory attributes and enabling storage at ambient temperature. The technology offers significant advantages in terms of convenience, transportation efficiency, and extended shelf life, making it particularly attractive for urban consumers and institutional markets (Venugopal, 2006; Majumdar et al., 2017). Emerging non-thermal preservation technologies are also receiving increasing attention in seafood processing. High-pressure processing, natural preservative systems, and other innovative approaches have demonstrated considerable potential for extending shelf life while minimizing adverse effects on nutritional and sensory quality. These technologies provide opportunities to enhance microbial safety and product stability without the extensive thermal damage often associated with conventional heat treatments (Rastogi et al., 2007; Misra et al., 2019; Olatunde and Benjakul, 2018; Gokoglu, 2019). Despite these advancements, adoption of modern processing technologies remains limited, particularly among small and medium enterprises (SMEs). High capital investment requirements, technical complexity, limited access to advanced equipment, inadequate infrastructure, and shortage of trained manpower continue to constrain widespread implementation. Consequently, a technological divide persists between large export-oriented processing facilities and smaller domestic processors. Bridging this gap will require targeted financial support, technology transfer programs, skill development initiatives, and improved access to infrastructure and institutional credit to facilitate modernization across the sector (Anonymous, 2022; Anonymous, 2023).

2.3. Post-harvest handling and quality management

The quality of processed fish products is fundamentally dependent on the condition of raw material entering processing plants. In India, post-harvest losses remain significant due to inadequate handling practices at landing centres, delayed icing, exposure to high ambient temperatures, and insufficient sanitation during harvesting and marketing operations (Huss, 1995; Nunes et al., 2007). Fish is highly perishable, and even short delays in chilling can result in rapid microbial proliferation, enzymatic activity, and biochemical spoilage, ultimately reducing shelf life, nutritional quality, and market value (Gram and Dalgaard, 2002; Ghaly et al., 2010). Transportation infrastructure also plays a critical role in maintaining fish quality. In several regions, fish is transported without adequate insulation, refrigeration, or temperature control, resulting in fluctuating storage conditions throughout the supply chain. Such practices contribute to increased formation of total volatile base nitrogen (TVB-N), lipid oxidation, microbial growth, and textural deterioration before processing begins (Huss, 1995; Ghaly et al., 2010). Furthermore, stress during harvesting, crowding, and rough handling can adversely affect muscle biochemistry and accelerate post-mortem deterioration, thereby compromising the quality of the final processed product (Love, 1997; Nunes et al., 2007). Quality management systems such as Hazard Analysis and Critical Control Point (HACCP), Good Manufacturing Practices (GMP), and Sanitation Standard Operating Procedures (SSOP) have been widely adopted in export-oriented seafood processing facilities. These systems improve hazard identification, process control, sanitation management, documentation, and traceability, thereby facilitating compliance with international food safety standards and regulatory requirements (Huss et al., 2000; Motarjemi and Lelieveld, 2014). Their implementation has significantly enhanced the safety and acceptability of Indian seafood products in global markets. Despite these improvements, consistent implementation of quality management systems remains challenging among small and medium enterprises (SMEs). Limited technical expertise, inadequate documentation practices, financial constraints, and insufficient awareness often hinder effective adoption of HACCP-based quality assurance programs. Strengthening training initiatives, extension services, infrastructure development, and regulatory monitoring is therefore essential to improve uniformity in quality management practices across the fish processing sector and reduce post-harvest losses (FAO Fisheries Technical Guidelines; Anonymous, 2023).

2.4. Traditional processing and domestic market orientation

Traditional fish processing methods continue to play a crucial socio-economic role, particularly in rural, coastal, and tribal communities throughout India. Sun drying, salting, fermentation, smoking, and related preservation techniques are widely practiced because of their low capital requirements, simplicity, and minimal dependence on sophisticated infrastructure (Bhalavey et al., 2025). These traditional methods contribute significantly to food security, livelihood generation, reduction of post-harvest losses, and preservation of seasonal fish surpluses, particularly in regions where access to cold chain facilities is limited. However, traditional processing practices often lack standardization with respect to drying conditions, salt concentration, fermentation control, moisture management, and hygienic handling procedures. Consequently, product quality may vary considerably between batches and locations. Inadequate sanitation and improper processing conditions can increase the risk of microbial contamination, insect infestation, oxidative deterioration, and other quality defects that adversely affect product safety and market acceptability (Bhalavey et al., 2025; Huss, 1995). Limited access to improved drying platforms, solar dryers, mechanical drying systems, and hygienic packaging technologies further constrains the competitiveness of traditional fish products in organized markets. At the same time, the domestic market for processed fish products is undergoing substantial transformation due to rapid urbanization, rising disposable incomes, changing lifestyles, and increasing awareness of the nutritional benefits of seafood consumption. Growing consumer demand for convenience foods has created new opportunities for ready-to-cook, ready-to-eat, chilled, and frozen seafood products. Organized retail chains, supermarket networks, and e-commerce platforms are increasingly facilitating the distribution and marketing of value-added seafood products across urban and semi-urban markets (Venugopal, 2006; Anonymous, 2023). The expansion of modern retail systems and changing consumer preferences have encouraged product diversification and innovation within the seafood processing sector. Development of convenience-oriented products, improved packaging systems, and enhanced cold chain logistics have expanded market opportunities for processors and entrepreneurs. Nevertheless, technological constraints, fragmented supply chains, inconsistent quality standards, and limited product innovation continue to restrict the sector's ability to fully capitalize on growing domestic demand. Strategic investments in processing modernization, skill development, cold chain infrastructure, quality assurance systems, and market-oriented product diversification are therefore essential to strengthen the competitiveness, profitability, and long-term sustainability of India's fish processing industry (Anonymous, 2022; Anonymous, 2023).

3. EMERGING TRENDS IN FISH PROCESSING TECHNOLOGY

3.1. Adoption of advanced and non-thermal processing technologies

Despite persistent infrastructural and operational challenges, the fish processing sector in India demonstrates significant growth potential driven by technological innovation, expanding domestic demand, export competitiveness, and supportive policy interventions. Rising consumer preference for safe, minimally processed, convenient, and protein-rich seafood products is accelerating modernization throughout the processing chain. Simultaneously, sustainability considerations, traceability requirements, and compliance with international quality standards are reshaping seafood processing practices. Conventional preservation methods such as icing, freezing, drying, and thermal processing continue to dominate the industry; however, emerging non-thermal technologies are receiving increasing attention because of their ability to improve microbial safety while preserving sensory and nutritional attributes. High-pressure processing (HPP), pulsed electric fields (PEF), cold plasma, ozone treatment, ultraviolet irradiation, and ultrasound-assisted processing have shown considerable promise for seafood preservation and shelf-life extension (Rastogi et al., 2007; Olatunde and Benjakul, 2018; Misra et al., 2019). High-pressure processing effectively inactivates spoilage and pathogenic microorganisms with minimal thermal damage, thereby extending refrigerated shelf life while maintaining desirable quality attributes. Similarly, ozone treatment, ultraviolet technologies, and cold plasma applications are being investigated as environmentally friendly approaches for reducing microbial contamination and enhancing seafood safety. These technologies align well with current consumer demand for clean-label foods that minimize the use of chemical preservatives (Misra et al., 2019; Gokoglu, 2019). Furthermore, the application of hurdle technology through strategic combinations of mild heat treatment, modified atmosphere packaging, and non-thermal interventions can further improve product safety and storage stability. Retort pouch processing and ready-to-eat seafood products are expanding rapidly in urban markets because of their convenience and ambient storage stability. Compared with conventional canning, retort processing often provides improved product quality, packaging flexibility, and consumer acceptability while maintaining commercial sterility. Growth of organized retail chains and e-commerce platforms has further stimulated demand for shelf-stable seafood products and convenience-oriented product formats (Venugopal, 2006; Majumdar et al., 2017).

3.2. Value addition and product diversification

Value addition remains central to enhancing profitability, improving resource utilization, and minimizing post-harvest losses within the fish processing sector. Development of surimi-based products, fish sausages, fish nuggets, restructured fillets, and functional seafood products enriched with omega-3 fatty acids has created substantial market opportunities. Increasing consumer awareness regarding protein nutrition, health-promoting foods, and functional ingredients has further strengthened acceptance of value-added seafood products (Venugopal and Shahidi, 1995; Venugopal, 2006). Utilization of low-value and underutilized fish species for mince-based and restructured products contributes significantly to resource efficiency, waste reduction, and income enhancement for fishers and processors. Technological advancements in cryoprotectant formulations, gel-strength improvement, and surimi processing have enhanced the quality and commercial viability of products manufactured from tropical fish species (Venugopal and Shahidi, 1995; Venugopal, 2006). In addition, fish protein hydrolysates, bioactive peptides, and other functional ingredients derived from processing streams have attracted growing attention because of their antioxidant, antihypertensive, antimicrobial, and nutraceutical properties. These developments are expanding opportunities for the utilization of fish-derived ingredients in functional foods, dietary supplements, and health-related applications (Roy et al., 2023; Rustad et al., 2011).

3.3. Sustainable processing and by-product utilization

Sustainability has become an integral component of modern fish processing strategies. Processing waste, which may constitute nearly 50–60% of the raw material depending on species and processing methods, represents a valuable resource when efficiently utilized. By-products such as heads, frames, viscera, skin, scales, and trimmings are increasingly processed for the extraction of fish oil, collagen, gelatin, enzymes, protein hydrolysates, and organic fertilizers (Rustad et al., 2011; Roy et al., 2023). The circular bioeconomy approach emphasizes the conversion of waste streams into high-value products for food, feed, pharmaceutical, nutraceutical, and cosmetic applications. Recent advances in enzymatic hydrolysis, membrane technologies, and environmentally sustainable extraction methods have improved recovery efficiency while reducing environmental impacts associated with seafood processing operations (Roy et al., 2023). Furthermore, sustainable water management practices, energy-efficient refrigeration and freezing systems, waste minimization programs, and biodegradable packaging materials are increasingly being incorporated into processing facilities to reduce their environmental footprint and improve resource efficiency. These developments support the long-term sustainability and economic viability of the fish processing industry (Anonymous, 2022; Roy et al., 2023).

3.4. Digitalization and smart processing systems

Digital transformation is gradually influencing seafood processing and supply chain management. Internet of Things (IoT)-enabled monitoring systems facilitate real-time measurement of temperature, humidity, and storage conditions throughout the cold chain, thereby improving product quality control and reducing post-harvest losses. Automated data collection systems also support more efficient inventory management and process monitoring (Ting et al., 2020). Artificial intelligence (AI)-based machine vision technologies are increasingly being explored for automated grading, defect detection, species identification, quality evaluation, and sorting operations. These technologies have the potential to improve processing efficiency, product consistency, and labor productivity while reducing human error in quality assessment. Blockchain-enabled traceability platforms are gaining importance in seafood supply chains because they enhance transparency, product authentication, and regulatory compliance. Such systems enable tracking of seafood products from harvest to final consumer, thereby supporting food safety requirements and strengthening consumer confidence. Digital integration of supply chain information can also improve decision-making, reduce inefficiencies, and facilitate compliance with increasingly stringent export market standards (Ting et al., 2020).

3.5. Policy support and capacity building

Government initiatives aimed at fisheries development increasingly emphasize infrastructure modernization, cold chain expansion, value addition, entrepreneurship promotion, and export competitiveness. Investments in processing facilities, cold storage infrastructure, transportation networks, and market development programs are contributing to strengthening the fish processing sector across major fish-producing regions of the country (Anonymous, 2022; Anonymous, 2023). Capacity building through targeted training programs, HACCP implementation, technology incubation initiatives, and public-private partnerships remain essential for accelerating adoption of advanced processing technologies. Continuous skill development and technical support are particularly important for small and medium enterprises seeking to improve product quality, operational efficiency, and regulatory compliance. Strengthening institutional linkages among research organizations, universities, extension agencies, and industry stakeholders will facilitate technology transfer and promote the commercialization of research innovations. Such collaborative efforts are expected to play a crucial role in achieving sustainable growth, enhancing value addition, and improving the global competitiveness of India's fish processing industry.

4. KEY CHALLENGES IN FISH PROCESSING TECHNOLOGY DEVELOPMENT IN INDIA

4.1. Inadequate cold chain infrastructure

One of the most critical bottlenecks in fish processing in India is the inadequacy of cold chain infrastructure from harvest to consumption. Fish is a highly perishable commodity, and even short interruptions in temperature control accelerate biochemical spoilage and microbial proliferation, leading to quality deterioration and economic losses (Ghaly et al., 2010; Huss, 1995).

In many inland and marine fisheries, the absence of onboard chilling facilities, insulated containers, and rapid icing systems results in delayed cooling immediately after harvest. This promotes the activity of spoilage microorganisms and endogenous enzymes, particularly under tropical environmental conditions (Gram and Dalgaard, 2002; Nunes et al., 2007). Limited availability of refrigerated transportation, cold storage facilities, and integrated cold chain networks in rural and semi-urban regions further aggravates post-harvest losses and reduces market value of fish products (Anonymous, 2022; Anonymous, 2023).

4.2. Microbial spoilage and food safety concerns

Microbial spoilage remains a major constraint in fish processing, particularly under inadequate hygiene and temperature control conditions. High initial microbial loads associated with contaminated water sources, unhygienic landing centers, and poor handling practices significantly increase the risk of spoilage and foodborne illnesses (Huss, 1995; Dalgaard, 2000).

Pathogenic microorganisms including *Vibrio* spp., *Salmonella* spp., *Listeria monocytogenes*, and *Staphylococcus aureus* have been reported in seafood products and represent significant food safety concerns. Their occurrence highlights the importance of effective sanitation, temperature control, and quality assurance systems throughout the processing chain (Jorgensen et al., 2000; Huss et al., 2000). Traditional processing methods such as sun drying, salting, fermentation, and smoking frequently lack standardized process controls, leading to variability in product quality and safety (Bhalavey et al., 2025).

Furthermore, compliance with international food safety requirements, including HACCP principles and sanitary and phytosanitary (SPS) regulations, remains inconsistent among small and medium-scale enterprises because of technical, financial, and infrastructural limitations (Huss et al., 2000).

4.3. Limited adoption of modern processing technologies

Although advanced fish processing technologies such as high-pressure processing, modified atmosphere packaging, pulsed electric fields, and retort pouch processing have gained considerable acceptance globally, their adoption in India remains relatively limited. High capital investment requirements, technological complexity, limited technical expertise, and inadequate awareness among processors continue to restrict the widespread diffusion of these technologies (Rastogi et al., 2007; Misra et al., 2019). Most processing facilities continue to depend primarily on conventional freezing, icing, and thermal processing techniques, which may not always provide optimum quality retention or maximum shelf-life extension (Venugopal, 2006). Emerging non-thermal technologies offer significant advantages in terms of nutrient retention, sensory quality preservation, and microbial safety; however, commercial implementation remains largely restricted to a limited number of export-oriented processing units (Olatunde and Benjakul, 2018; Misra et al., 2019).

4.4. Skill gaps and manpower constraints

The fish processing sector continues to face shortages of adequately trained personnel across operational, technical, and managerial levels. Many workers engaged in fish handling and processing lack formal training in hygiene management, quality control procedures, food safety standards, and advanced processing technologies. This frequently results in inconsistencies in product quality, reduced operational efficiency, and increased product rejection rates (Anonymous, 2022; Anonymous, 2023). Limited interaction between academic institutions, research organizations, and processing industries further contributes to skill gaps, particularly in emerging areas such as value-added product development, cold chain management, quality assurance, and advanced seafood processing technologies. Strengthening industry–academia collaboration, vocational training programs, and technology incubation initiatives is therefore essential for improving workforce competency and supporting sectoral modernization.

4.5. Regulatory and market access challenges

The regulatory framework governing fish processing and seafood exports in India involves multiple regulatory agencies and certification requirements, which may create procedural complexities, particularly for small-scale processors. Compliance with regulations related to traceability, residue monitoring, food safety certification, and export documentation often requires significant financial and technical resources (Anonymous, 2023; Anonymous, 2022). In addition, fluctuations in international market demand, changing import regulations, increasing quality expectations, and competition from other seafood-exporting countries continue to influence the competitiveness of Indian seafood products. Rejections arising from quality deficiencies, documentation issues, or non-compliance with importing-country standards can significantly affect export performance and profitability. Therefore, strengthening traceability systems, quality assurance programs, regulatory support mechanisms, and market intelligence services remains essential for sustaining long-term growth of the fish processing sector.

5. CONCLUSION

The review examined the status, challenges, and future prospects of fish processing technology in India. It highlighted infrastructural gaps, cold chain deficiencies, microbial risks, and limited adoption of advanced technologies as key constraints affecting quality and competitiveness. The study also identified opportunities in value addition, sustainable by-product utilization, digitalization, and non-thermal processing technologies. It concluded that integrated technological innovation, capacity building, and policy support were essential for strengthening and modernizing the fish processing sector in India.

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