International Journal of Science, Environment and Technology, Vol. 14, No 6, 2025, 609 – 616
ISSN 2278-3687 (O)
2277-663X (P)

Review Paper

A COMPREHENSIVE REVIEW OF GLOBAL CHALLENGES AND OPPORTUNITIES IN POULTRY SLAUGHTER HOUSE WASTE HANDLING

R. Rajkumar*
Veterinary College and Research Institute, Theni-625534,
(Tamilnadu Veterinary and Animal Sciences University)
E-mail: rajkumarvet@gmail.com (**Corresponding Author*)

Introduction

The poultry sector ranks among the most dynamically expanding segments of the global livestock industry. This rapid growth, particularly in commercial broiler production, has precipitated a parallel surge in slaughter and processing activities worldwide. A fundamental reality of these operations is the generation of substantial organic waste, which constitutes 20–30% of a bird's live weight. This includes a wide spectrum of materials from blood, feathers, and viscera to offal, heads, feet, bones, and processing wastewater. The sheer volume of these by-products makes their management a critical operational, economic, and environmental imperative for the industry.

When managed improperly, these organic wastes pose significant threats, including water pollution, soil contamination, odour nuisance, and the spread of pathogens. Conversely, when collected and processed with scientific precision, they are transformed from a disposal problem into valuable raw materials. These by-products form the foundation for a range of secondary industries, including rendering, animal feed production, fertilizer manufacturing, bioenergy, and even pharmaceuticals.

Globally, the scale of this waste stream is immense, with tens of millions of tonnes generated annually, driven by high-production nations like the United States, Brazil, and China, as well as the European Union. In these developed regions, the industry is characterized by highly integrated, mechanized processing plants equipped with advanced rendering facilities. This infrastructure enables a near-total valorisation of by-products, converting them into meat and bone meal, feather meal, blood meal, poultry fat, and biogas. Stringent environmental regulations and modern technologies have been instrumental in pushing these countries

*Received Nov 28, 2025 * Published Dec 5, 2025 * www.ijset.net*

toward sophisticated, near-zero-waste systems where organic by-products are consistently recycled.

India's position in this global landscape is one of striking contrast. The country has experienced a dramatic expansion in poultry production over the past two decades, cementing its status as one of the world's largest producers of broiler meat and eggs. However, its waste management infrastructure has not kept pace. A major share of slaughtering occurs in small, semi-formal, or informal units, leading to a fragmented and inconsistent approach to waste utilisation. While large, organised processing plants mirror global best practices efficiently converting by-products into rendered materials and biogas. The smaller, unorganised sector often lacks the necessary systems, resulting in the improper disposal of valuable resources through open dumping, drainage discharge, or landfilling.

Annually, India is estimated to produce between 1.7 and 2.1 million tonnes of slaughterhouse by-products (excluding poultry litter), a figure that underscores both a significant environmental challenge and a substantial untapped economic opportunity. The management of poultry slaughterhouse waste thus presents a clear divergence between India and more developed nations. Bridging this gap requires a multi-faceted approach: strengthening waste collection networks, establishing regional rendering plants, and promoting the adoption of modern bioconversion technologies. By doing so, India can align with global best practices, transitioning its poultry sector from a linear model of waste generation to a sustainable, circular system that views every by-product as a resource

1.Categories of Poultry Slaughterhouse Waste

The major waste and by-product categories generated during poultry slaughtering and processing include:

Viscera and Edible Offal: The Nutrient-Dense Harvest

The viscera and edible offal, commonly known as giblets which include the heart, liver, and gizzard constitute a significant portion of the live bird, accounting for approximately 5 to 7 percent of its weight, which translates to an annual production exceeding 300,000 metric tonnes in India. These components are far from mere waste; they are, in fact, nutrient-dense products characterized by high protein content ranging from 15 to 20 percent, relatively low fat levels between 3 and 10 percent, and a high moisture content of around 70 to 75 percent. Their true value lies in their active components: the liver is exceptionally rich in vital vitamins A, B12, and D, as well as minerals like iron and copper, while the heart serves as a good source of coenzyme Q10 and essential amino acids, and the gizzard provides robust

muscular protein and collagen. Consequently, these offals are meticulously collected, cleaned, and chilled within the organised sector to be sold as high-value human food in domestic markets and for export, with wastage being minimal due to their esteemed status in various cuisines and their direct contribution to nutritional security.

Heads, Feet, and Trimmings: From Culinary Staples to Industrial Raw Materials:

Heads, feet, necks, and trimmings represent another substantial by-product stream, making up about 8 to 10 percent of the live bird's weight. This category boasts a diverse composition, being high in protein, primarily in the form of collagen and keratin from the skin and feet, at levels of 13 to 18 percent, and containing substantial fat content of 15 to 20 percent. The key active components that elevate their value are collagen and gelatin, with chicken feet being a particularly rich source of chondroitin sulphate and glucosamine, compounds highly valued for joint health, while the bone content provides essential minerals like calcium and phosphorus. Utilisation is therefore multifaceted; they are sold directly as popular items in human cuisine across India and for export, and through the process of rendering, they are converted into high-quality poultry fat and protein meal for animal feed, with an emerging trend of extracting their bioactive compounds for the nutraceutical industry.

Feathers: The Keratin Challenge and Opportunity

Feathers, making up 5 to 7 percent of the live bird weight and amounting to hundreds of thousands of tonnes annually, present one of the most abundant yet challenging waste streams. Their composition is dominated by protein, approximately 90 percent on a dry matter basis, but this protein is primarily in the form of keratin, a tough, fibrous, and cross-linked polymer that is indigestible for most animals due to its structure and deficiency in certain essential amino acids like methionine and lysine. The key active component, therefore, is the keratin itself, along with a high nitrogen content. To unlock this value, the organised sector employs hydrolysis, a process using heat and pressure to break down the keratin bonds, transforming feathers into a digestible hydrolysed feather meal used primarily as a slow-release nitrogen source in ruminant feed and fertilizer, while ongoing research explores microbial and enzymatic methods to produce keratin for more advanced applications in bioplastics and biomaterials.

Blood: A Potent Sourse of High-Quality Protein

Blood, representing 3 to 4 percent of the live weight, is a potent and valuable fluid stream, yet its collection remains a challenge, particularly in smaller processing units. Its composition is marked by high moisture content of around 80 percent, but on a dry basis, it possesses an

exceptional protein content of 90 to 95 percent, comprising a rich balance of plasma proteins like albumin and globulins, and cellular proteins like hemoglobin. The active components include immunoglobulins, heme iron a highly bioavailable form of iron—and various bioactive peptides. When collected hygienically, blood is spray-dried to produce blood meal, a premier, lysine-rich protein supplement for livestock and fish feed; furthermore, technologies exist to separate plasma for high-value animal feed and to extract heme iron for use in food fortification, making efficient blood collection a critical economic and environmental imperative.

Bones and Carcass Frames: A Mineral and Protein Repository

After deboning, the remaining bones and carcass frames constitute a significant 15 to 20 percent of the carcass, serving as a rich repository of both protein and minerals. Their proximate composition is a complex mix of protein, largely collagen at around 20 percent, fat at approximately 15 percent, and a high mineral or ash content of 60 to 70 percent. The key active components are the mineral phase, primarily hydroxyapatite—a calcium-phosphate complex and the organic matrix, rich in collagen, gelatin, and bone marrow containing growth factors and lipids. Through rendering, these frames are converted into two main products: bone meal, a slow-release phosphorus and calcium fertilizer, and poultry by-product meal, a high-protein ingredient for pet food and animal feed, with advanced processing allowing for the extraction of gelatin and bioactive lipids from the marrow.

Wastewater and Sludge: The Liquid Burden with Energy Potential

Poultry slaughterhouses are highly water-intensive, generating between 10 to 25 litres of wastewater per bird processed, a stream characterized by a high organic load from blood, fat, and manure, leading to severely elevated Biological and Chemical Oxygen Demand (BOD/COD). This wastewater is a complex slurry containing suspended solids, dissolved proteins, fats, carbohydrates, and essential plant nutrients like Nitrogen, Phosphorus, and Potassium (N-P-K). The active components are precisely these organic compounds and nutrients, which, while polluting if discharged untreated, become valuable resources when processed through Effluent Treatment Plants (ETPs), where microbial digestion breaks down the organics to produce biogas a renewable energy source and the resulting stabilised sludge serves as a potent bio-manure, closing the loop on this liquid waste stream.

Dead-on-Arrival Birds and Hatchery Waste: Managing Biosecurity and Nutrients:

The inevitable occurrence of Dead-on-Arrival (DOA) birds, accounting for 0.5 to 1 percent of transported poultry, along with hatchery waste like infertile eggs and shells, constitutes a

waste stream that demands careful management due to its high biosecurity risk. This material has a composition similar to a whole bird, being high in protein (~18%), fat (~15%), and moisture (~60%), with hatchery waste adding the specific component of eggshells, which are primarily composed of calcium carbonate. The active components are the full spectrum of nutrients, but they are packaged with potential pathogens. Therefore, the primary utilisation methods are rendering, which sterilizes the material and concentrates the nutrients into a safe poultry by-product meal for animal feed, and composting, which safely recycles the nutrients into organic fertilizer, while crushed eggshells can be directly used as a calcium supplement.

Litter and Manure: The Farm-Level Resource

The largest waste stream by volume originates directly from the farms, where a single bird produces approximately 1 to 1.5 kg of litter—a mixture of poultry excreta, undigested feed, and bedding material like rice husk or wood shavings. This litter is a nutrient-rich resource, abundant in organic matter and the essential macronutrients Nitrogen (N), Phosphorus (P), and Potassium (K). The active components are these very N-P-K nutrients and the organic carbon, which are driven by a diverse microbial consortium. Its primary and most beneficial use is as a high-quality organic manure to improve soil health, while a growing and highly sustainable practice involves using it in bio-methanation plants to produce biogas for renewable energy, leaving behind a nutrient-rich digestate that can also be used as fertilizer.

The journey of poultry waste in India, from a perceived environmental burden to a recognized generator of wealth, hinges entirely on a science-led understanding of its unique composition. Each stream, from the keratin-rich feathers to the mineral-dense bones and the nutrient-packed blood, holds a specific key to a valuable application, whether in feed, fertilizer, energy, or industry. The path forward requires targeted technology transfer and policy support, especially for the unorganised sector, to implement cost-effective, small-scale rendering, composting, and bio-digestion solutions. By strategically aligning waste management practices with the inherent biochemical potential of these streams, the Indian poultry industry can fully embrace a sustainable, profitable, and circular model, truly transforming its "waste into worth" and solidifying its role as a responsible and efficient sector for the future.

Edible Use of Specialty Parts

Many developed and developing countries utilise by-products as food, increasing profitability:

- **Chicken feet (paws):** China, Vietnam, Thailand, Philippines

- **Liver, heart, gizzard:** USA, Europe, Africa, Middle East
- **Necks and carcass frames:** Japan, Korea, USA (soups, broths)
- **Skin and fat:** USA, Mexico, Japan (crispy skin snacks, chicken oil)

This edible utilisation adds significant economic value, especially in export markets.

High-Value Bio-products

Feathers are processed to extract **keratin** for cosmetics, biodegradable films, fibres, and biomedical applications. Bones and skin yield **collagen, gelatin, and peptides**, used in nutraceuticals.

Countries Using Poultry By-Products as Edible Products

By-Product	Countries	Edible Product Examples
Chicken feet	China, Vietnam, Philippines	Braised feet, collagen snacks
Gizzards	USA, Brazil, EU	Fried gizzards, canned gizzards
Liver & heart	Middle East, Europe, Asia	Kebabs, pâté, stir-fries
Necks	Japan, Korea, USA	Broth, soup stock
Carcass frames	USA, Canada	Bone broth, mechanically deboned meat
Skins & fat	USA, Japan, Mexico	Crispy skin, chicken oil

These markets demonstrate the economic potential of what many countries consider low-value by-products.

Conclusion:

Poultry slaughterhouse wastes have significant economic value, but their utilisation varies widely between India and developed countries. In India, organised processing plants efficiently convert many waste streams into by-products such as feather meal, blood meal, and Meat cum bonemeal, but a large proportion of slaughter occurs in informal setups where waste disposal is poorly managed. This leads to environmental pollution and economic loss. In contrast, developed nations follow integrated, regulated, and technologically advanced systems that achieve near-zero waste by converting almost every component into marketable food, feed, fuel, or industrial products. Countries such as China, the USA, Brazil, and Japan also utilise several poultry by-products as edible items, further enhancing profitability. Strengthening waste management infrastructure, promoting rendering and biogas units, and

creating markets for edible by-products can significantly improve India's utilisation efficiency and align the industry with global best practices.

The divergence in poultry waste management between West and Southeast Asia is a tale of regulation, infrastructure, and economic prioritisation. The West demonstrates a closed-loop, high-value model where waste is a designed output. Southeast Asia, and India in particular, operates a dual system: a modern, efficient sector coexisting with a vast informal one where waste is a costly by-product. For India and its regional neighbours, the path forward lies in policy support for decentralised rendering and biogas units, technology transfer for affordable treatment solutions, and stricter enforcement to curb pollution. By learning from Western circular models while adapting to local contexts, these countries can turn their poultry waste challenge into a cornerstone of sustainable agricultural growth.

References

[1] Alvarado, C. Z., & Sams, A. R. (2017). *Poultry meat processing* (2nd ed.). CRC Press.

[2] Central Pollution Control Board. (2016). *Guidelines for management of poultry waste*. Ministry of Environment, Forest and Climate Change, Government of India.

[3] Central Pollution Control Board. (2017). *Guidelines for poultry, hatchery and slaughterhouse management*. Ministry of Environment, Forest and Climate Change, Government of India.

[4] Department of Animal Husbandry & Dairying. (2023). *Basic animal husbandry statistics (BAHS)*. Government of India.

[5] European Commission. (2015). *Best available techniques (BAT) reference document for the slaughterhouses and animal by-products industries*.

[6] European Commission. (2016). *Best available techniques (BAT) in the slaughterhouses and animal by-products industries*.

[7] FAO. (2003). *Poultry meat & eggs: Agribusiness handbook*. Food and Agriculture Organization of the United Nations.

[8] Food and Agriculture Organization. (2013). *Poultry waste management*. FAO.

[9] Feddes, J. J., & Fraser, D. (1999). Nutritional value of feather meal. In *Biotechnology in animal feeds and feeding*.

[10] ICAR – Directorate of Poultry Research. (Various years). *Poultry statistics and nutrient composition of by-products*.

[11] Jayathilakan, K., Sultana, K., Radhakrishna, K., & Bawa, A. S. (2012). Utilization of byproducts and waste materials from meat, poultry and fish processing industries: A review. *Journal of Food Science and Technology, 49*(3), 278–293.

[12] Kelleher, B. P. (2002). Generation, treatment and use of poultry litter. *World's Poultry Science Journal, 58*, 231–254.

[13] Lasekan, A., et al. (2013). Extraction and characterization of keratin from chicken feathers. *Journal of Chemistry*.

[14] Liu, D. C. (2003). *Better utilization of by-products in the chicken processing industry*. Taiwan Livestock Research Institute Technical Bulletin.

[15] Mead, G. C. (2004). *Poultry meat processing and quality*. Woodhead Publishing.

[16] Ministry of Fisheries, Animal Husbandry & Dairying. (2023). *Basic animal husbandry statistics*. Government of India.

[17] Nambiar, P. R., & Ramachandran, K. (2013). Poultry slaughterhouse waste management practices and utilization. In *Environmental implications of poultry production*. Springer.

[18] National Renderers Association. (2021). *The essential role of rendering*.

[19] Northcutt, J. K., & Savage, S. I. (1997). *Poultry processing wastewater management handbook*. University of Georgia Cooperative Extension Service.

[20] Ockerman, H. W., & Hansen, C. L. (2000). *Animal by-product processing & utilization*. CRC Press.

[21] Sharma, B., & Dhull, S. (2015). Management of animal slaughterhouse wastes in India: An overview. *Journal of Environmental Science and Technology, 8*(3), 93–103.

[22] Simons, P. C. M. (2012). Value addition to poultry by-products in the European Union. *World's Poultry Science Journal, 68*(2), 331–343.

[23] Taufiq, M., et al. (2019). Poultry slaughterhouse waste management in Southeast Asia: A review. *IOP Conference Series: Earth and Environmental Science*.

[24] USDA Foreign Agricultural Service. (2023). *Poultry and products annual reports: Global poultry market overview*. United States Department of Agriculture.