# IPSACON 2025

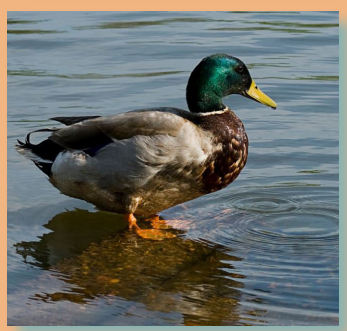
## 40th Annual Conference & National Symposium of Indian Poultry Science Association on

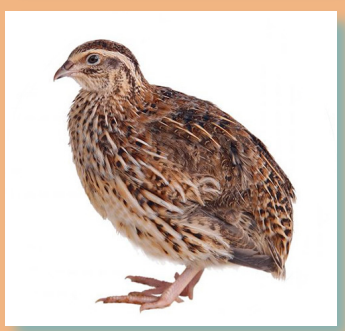
**"Flock to the future: Embracing technology, innovation, entrepreneurship and sustainability in poultry production for protein security in Viksit Bharat"**

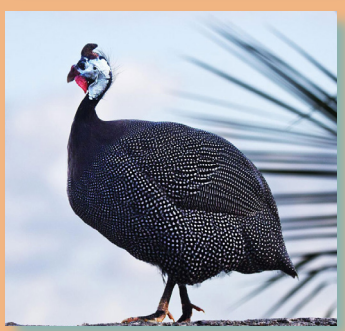
**9th - 11th December 2025**

## Volume - I

## Keynote and Lead Papers







**Organized by**


**ICAR-Directorate of Poultry Research**

**Rajendranagar, Hyderabad-500 030, Telangana, India**

**Indian Poultry Science Association**


IPSACON 2025

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## INDIAN POULTRY EQUIPMENT MANUFACTURERS ASSOCIATION

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## on

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**Rajendranagar, Hyderabad-500 030, Telangana, India**

**Indian Poultry Science Association**

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**No. AS/PS/DDG(AS)/Message/2025**
**Dated 21st November, 2025**

## MESSAGE

It is indeed heartening to learn that the Indian Poultry Science Association (IPSA) and the ICAR–Directorate of Poultry Research, Hyderabad, are jointly organizing the 40th Annual Conference and National Symposium on 'Flock to the Future: Embracing Technology, Innovation, Entrepreneurship and Sustainability in Poultry Production for Protein Security in Viksit Bharat, scheduled to be held from 9–11 December 2025 at the ICAR–DPR, Hyderabad. The theme of this symposium is both timely and highly relevant, especially in the context of Viksit Bharat 2047 and the nation's pursuit of self-reliance across various domains of the poultry sector through the adoption of cutting-edge technologies.

The Indian poultry industry has demonstrated consistent growth over the past decades. It continues to embrace advanced knowledge and innovations to enhance productivity, ensure bird welfare, and strengthen sectoral efficiency. Young entrepreneurs are increasingly driving this transformation by adopting creative solutions to address industry challenges and provide seamless services to consumers.

Value addition in chicken meat and egg processing represents a high-potential niche where innovative technologies can play a crucial role in minimizing post-harvest losses and reducing environmental impact—key steps toward achieving sustainable poultry production. Equally important is the expanding use of AI and IoT in poultry farming and processing, which is helping maintain high welfare standards and improve overall system efficiency.

I commend the organizers for this important initiative. I am confident that the symposium will offer a valuable platform for scientists, policymakers, and all stakeholders to deliberate on cutting-edge research and collectively develop an actionable roadmap to advance the vision of Viksit Bharat.

I extend my best wishes for the grand success of the conference.

(Raghavendra Bhatta)

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**Dr Gyanendra Kumar Gaur**
Assistant Director General (AP& B)

Dated the 21st November 2025

# Message

It gives me immense pleasure to state that ICAR-Directorate of Poultry Research, Hyderabad is organizing the 40th Annual Conference of Indian Poultry Science Association 2025 (IPSACON 2025) and National Symposium from 9th to 11th December 2025 at Hyderabad.

I extend my warm greetings and best wishes to all delegates, researchers, industry partners, and students participating in the 40th Annual Conference of the Indian Poultry Science Association (IPSA). This milestone conference marks four decades of IPSA's dedicated service to the advancement of poultry science, research, and industry development in India.

The Indian poultry sector continues to be one of the fastest-growing and most vibrant components of our agricultural economy. The contributions of scientists, academicians, entrepreneurs, and policymakers have been instrumental in transforming India into one of the global leaders in poultry production. Yet, as we look ahead, we must remain committed to addressing emerging challenges from feed security and disease control to climate resilience, welfare standards, sustainability, and technological innovation.

The theme of this year's conference (Flock to the future: Embracing technology, innovation, entrepreneurship and sustainability in poultry production for protein security in Viksit Bharat) aptly reflects our collective aspiration to promote innovation, sustainability, and inclusivity in the poultry sector. I am confident that the deliberations, technical sessions, and interactions during this conference will inspire new ideas, strengthen collaborations, and chart pathways for the continued growth of the sector.

In this regard, I express my deep appreciation to the organizing committee, host institution, sponsors, and all contributors for their tireless efforts in making this conference a grand success. I also extend a hearty welcome to all participants and wish you an intellectually stimulating and enriching experience.

[Gyanendra Kumar Gaur]

**Dr. P.K. Shukla**
**President**

**Indian Poultry Science Association**
Central Avian Research Institute
Izatnagar, Bareilly, UP

# Message

It gives me immense pleasure to extend my warm greetings and best wishes on the occasion of the **40th Annual Conference and Symposium of the Indian Poultry Science Association (IPSACON–2025)**. The Indian Poultry Science Association, through its more than four decades of dedicated scientific service, has continually strived to enrich the nation's poultry sector with innovation, knowledge-sharing and professional excellence. This landmark year is a proud reminder of our collective commitment to advancing poultry science for national development.

The theme of this year's conference **"Flock to the Future: Embracing Technology, Innovation, Entrepreneurship and Sustainability in Poultry Production for Protein Security in Viksit Bharat"** is both timely and visionary. As India moves steadfastly toward the goal of *Viksit Bharat @2047*, the role of the poultry sector in ensuring affordable, accessible and high-quality protein for all citizens becomes increasingly critical. Achieving this vision demands a robust integration of cutting-edge technologies, digital tools, climate-smart practices, forward-looking entrepreneurship, and sustainable production systems across the poultry value chain.

I am delighted that **ICAR–Directorate on Poultry Research (DPR), Rajendranagar, Hyderabad** is hosting this prestigious event. ICAR-DPR has consistently contributed to scientific leadership, genetic improvement, disease management, and capacity building for the benefit of farmers, industry stakeholders and policymakers. Their efforts, combined with the vibrant scientific fraternity and progressive industry partners, promise a highly enriching and impactful conference.

This Souvenir-cum-Abstracts volume captures the intellectual essence of IPSACON–2025. The diverse research contributions contained herein reflect the scientific rigor, innovation and future-oriented thinking of our researchers, academicians, and students. I am confident that the discussions, deliberations and collaborations emerging during this conference will catalyse new pathways for sustainable growth, entrepreneurship, and technological transformation in the Indian poultry sector.

On behalf of IPSA, I extend my sincere appreciation to the Organising Committee, ICAR-DPR, sponsors, contributors, and all delegates for their dedication and active participation. Let us continue to work together with renewed energy to strengthen poultry science for a nutritionally secure and prosperous India.

I wish IPSACON–2025 grand success and enduring outcomes.

**(P. K. Shukla)**
**President**
**Indian Poultry Science Association**

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**ICAR-DIRECTORATE OF POULTRY RESEARCH**

**(Receipent of Sardar Patel Best Outstanding Institute Award for the year 2013)**

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**डॉ. आर एन चटर्जी**

निदेशक, (भाकृअनुप - कुककुट अनुसंधान निदेशालय)

**Dr. R N Chatterjee**

**Director, (ICAR-Directorate of Poultry Research)**

# MESSAGE

It is a privilege and honor to organize the 40th Annual Conference of Indian Poultry Science Association 2025 (IPSACON 2025) and National Symposium at the ICAR-Directorate of Poultry Research, Hyderabad during 9th to 11th December 2025. Over the past four decades, IPSA has played a pivotal role in bringing together scientists, academicians, entrepreneurs, policymakers, and industry stakeholders to deliberate on advances and challenges in poultry science and production.

The Indian poultry industry continues to be one of the fastest-growing components of the livestock industry, contributing significantly to the nation's nutritional security, rural livelihood, and economic growth. Sustaining this momentum calls for continual innovation—through cutting-edge research, improved production systems, enhanced disease resilience, and sustainable resource management. In this context, IPSACON-2025 provides a vital platform to share scientific knowledge, novel technologies, and visionary ideas that can drive the sector towards resilience and sustainability.

ICAR–Directorate of Poultry Research has been at the forefront of developing need-based technologies for different poultry production systems, including germplasm improvement, nutrition, health management, industry support through contract research, etc. I am confident that this conference will further strengthen collaborations among research institutions, universities, and the poultry industry to address emerging challenges and harness new opportunities.

The organizers have aptly selected the theme of the conference "Flock to the future: Embracing technology, innovation, entrepreneurship and sustainability in poultry production for protein security in Viksit Bharat" keeping in view the need for utilizing the evolving technologies, innovations and entrepreneurial skills to enhance the productivity of the poultry sector to ensure protein security for all the people of Viksit Bharat in a sustainable manner. I hope the deliberations will cover the entire gamut of these important areas to come up with the recommendations to enhance the productivity of poultry and address the challenges faced by all the stakeholders of the poultry sector in India.

I extend my heartfelt thanks to the organizers for taking initiative to host this landmark 40th Annual Conference. I wish all delegates fruitful deliberations and a memorable experience at IPSACON-2025.

**(Dr. R. N. Chatterjee)**

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भाकृअनुप - कुककुट अनुसंधान निदेशालय
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Rajendranagar, Hyderabad 500 030 Telangana, India

***Dr. U. Rajkumar***
***Organizing secretary***

# MESSAGE

It is a great honor and privilege to organize the 40th Annual Conference of Indian Poultry Science Association 2025 (IPSACON 2025) and National Symposium at the ICAR-Directorate of Poultry Research, Hyderabad during 9th to 11th December 2025 on the pertinent theme "Flock to the future: Embracing technology, innovation, entrepreneurship and sustainability in poultry production for protein security in Viksit Bharat"

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This conference is the right platform to bring various stakeholders under one roof to discuss needs of poultry industry and poultry farmers of the caountry. Embracing the advanced technologies and innovations for sustainable poultry production and productivity is the need of the hour to ensure the protein and nutritional security in aspirational India. Through this Conference we will put all our effort to drive the national policy to tackle the important burning issues of poultry sector with suitable recommendations for consideration of the Government of India. The thematic talks and the technical sessions will drive you through the various aspects of poultry from breeding, nutrition, health, housing and management, post-harvest processing, marketing, welfare etc. This Conference provides an excellent opportunity to showcase and present the ideas, thoughts, innovations, and developments that could benefit the poultry fraternity.

I gratefully acknowledge the financial support received from Indian Council of Agricultural Research and all the sponsors of the IPSACON 2025 for making the event a memorable one.

I whole heartedly thank the speakers for accepting our invitation to share their wisdom. I thank all the delegates for their overwhelming response and great enthusiasm shown towards the IPSACON 2025. My thanks are due to Director and the scientists of ICAR-DPR and all the committees for their cooperation in making all the necessary arrangements for successfully organizing the conference. I express sincere thanks to IPSA for entrusting us with the responsibility to organize this important event.

All efforts are made to ensure that your stay in Hyderabad be one of the most memorable one and you go back with rich scientific information and wisdom.

On behalf of the organizing Committee, I extend a warm welcome to all the delegates to the 40th Annual Conference of IPSA.
Best Wishes

(U. Rajkumar)

**Dr. Simmi Tomar**
**General Secretary**

**Indian Poultry Science Association**
Central Avian Research Institute
Izatnagar, Bareilly, UP

# Message

It is a matter of great pride to present the Compendium of the **40th Annual Conference & National Symposium of the Indian Poultry Science Association (IPSACON-2025)**, being organized from **9–11 December 2025** on the theme **"Flock to the future: Embracing technology, innovation, entrepreneurship and sustainability in poultry production for protein security."**

The conference theme reflects our collective commitment to harness modern technologies, sustainable practices and entrepreneurial spirit to strengthen India's poultry industry and ensure long-term protein security.

A notable initiative this year is the **introduction of the Quiz Competition for Postgraduate Poultry Science Students**, being held for the first time under the IPSACON banner. This endeavour is intended to inspire young minds, promote healthy academic competition and encourage deeper student participation in professional scientific activities.

IPSA today stands strong with a membership of **1880 committed professionals**, and continues to serve as a unique platform for networking, knowledge exchange and capacity building in poultry science. I am confident that the contributions included in this compendium — research papers and abstracts— will be of immense value to researchers, students and professionals.

I extend my sincere appreciation to all authors, reviewers, sponsors and organizers for their dedicated efforts in making this conference and compendium a success. My best wishes to all participants for meaningful deliberations and a memorable academic experience.

I wish the organizers success in their endeavour

**(Simmi Tomar)**

# Host Institute

# ICAR-Directorate of Poultry Research in the Service of the Nation

The ICAR–Directorate of Poultry Research (formerly Project Directorate on Poultry) was established on 1st March 1988 at Hyderabad, Andhra Pradesh under the aegis of Indian Council of Agricultural Research. The Institute originated from All India Coordinated Research Project (AICRP) on Poultry Breeding, an all India Network project launched by the Indian Council of Agricultural Research during IV five-year plan with the objective of augmenting commercial poultry production and achieving self-sufficiency in the country.

In the beginning, the coordinating unit of AICRP was located at the Poultry Research Division, Indian Veterinary Research Institute, Izatnagar till 1979, which later shifted to Central Avian Research Institute, Izatnagar till its elevation to the Directorate status in 1988 with its headquarters at Hyderabad. The institute was elevated from Project Directorate to Directorate on 18th September 2013. The Regional Station, Bhubaneswar was transferred from ICAR-CARI to ICAR-DPR during July 2020. Accordingly, the total scientific strength of DPR has increased to 33.

The primary research focus at the Institute has been towards the application of quantitative genetic principles to enhance productivity of various chicken germplasm with special emphasis to meet the needs of rural and tribal people. Research on nutrition, health, physiology and molecular genetics supports the core breeding programme. In addition, several externally funded projects were carried out to achieve the Institute's goals and objectives. Directorate received Sardar Patel Best Institute Award 2013 from Honourable PM. Directorate is ISO 9001-2015 certified institution.

## Vision

To enhance productivity of chicken for household nutritional security, income and employment generation.

## Mission

To develop and propagate improved chicken varieties for sustainable production under intensive and extensive systems.

## Mandate

1. Basic and applied research to enhance productivity of poultry
2. Development of new germplasm for rural poultry husbandry
3. Capacity building

The Directorate developed popular rural varieties such as Vanaraja (dual-purpose), Gramapriya (layer), Srinidhi (dual-purpose), Janapriya (dual-purpose) and Aslibro (meat type). Vanashree (PD-4), developed from Aseel, is being popularised across India. Two commercial crosses were developed: Krishibro (multi-coloured broiler) and Krishilayer (high-yield egg-layer). Research is ongoing to develop new crosses for diverse backyard conditions.

Native chicken specific medium density 74K SNP chip, 'INDICHICK' chicken SNP, a product developed for GWAS/Genomic Selection. Transgenic chicken as a bioreactor was developed for producing human interferon alpha 2b in eggs. Knocking down Acetyl-CoA Carboxylase type A (ACACA) and sterol regulatory element-binding protein 1 (SREBP1) genes in chicken reduced cholesterol content in eggs. Genome editing of inhibin alpha gene in Nicobari chicken and prolactin gene in Kadaknath by CRISPR/cas9 improved egg production significantly. A high-quality chromosomal-level Kadaknath de novo haplotype-resolved genome has been assembled. Transgenic chickens were developed as bioreactors for the expression of human therapeutic proteins, namely tissue plasminogen activator (htPA) and erythropoietin (hERP) and for expression of Bovine lactoferrin.

Standardization of nutritional requirements of chicken and duck and identification of novel/alternate feed ingredients. Alternatives sources of protein (for Soybean) in poultry diet established- Cotton seed meal, guar meal, sesame cake, sunflower cake, DDGS, karanj cake etc. established. Alternative sources of energy (for maize) in poultry diet established- Pearl millet, finger millet, sorghum, broken rice, foxtail millet etc. Developed feed additives, DPR-EubioticA and herbal growth promoter (HGP) as a replacement for antibiotic growth promoters in broiler chicken production. Vitamin D3 and microbial phytase were identified as potential alternatives for inorganic phosphorus in poultry diets. Measures for counteracting mycotoxin in poultry diets were developed.

The incidence of avian leukosis virus (ALV) in the purelines was reduced significantly (less than 2%) by screening through P27 antigen ELISA. A duplex PCR assay was developed for screening Mycoplasma in poultry. Developed the protocol for cryopreservation of chicken spermatozoa with success rate varying from 30-60% in different native breeds and purelines. Cryopreservation of primordial germ cells (PGCs) of 11 indigenous chicken breeds viz. Hansli, Kadaknath, Ghagus, Aseel, Nicobari, Mewari, Panjab Brown, Ankleshwar, Tellichery, Aravalli and Daothigir were cryopreserved as part of conservation. A desktop-based comprehensive chick vocalization data analysis tool, Charpelizer, ver. 1.3, has been developed in collaboration with CDAC-Kolkata to automate gender detection of day-old chicks.

DPR has been recognized as the Hyderabad Hub of ICAR-IVRI, Izatnagar, to offer full-fledged postgraduate (MVSc, PhD) programs in Poultry Science. Academic activities commenced from 2023-24 with five MVSc and three PhD students enrolled. During 2024-25, six MVsc and three PhD students enrolled. The institute also contributes to ICAR-CRIDA, Hyderabad Hub of ICAR-IARI Mega University for UG programs.

## Regional Station, Bhubaneswar

Recognizing the slow development of poultry in Eastern and North-Eastern India, the Regional Centre of CARI (now under DPR since July 2020) was established to focus on duck production. The centre has units of Avian Genetics, Production Management, Nutrition, Physiology, Extension, Medicine, Hatchery, farms and feed technology. Duckling and egg supply are the major revenue generators. The centre was established on 26 July 1992 at Choudwar, Cuttack. It shifted to Bhubaneswar in 1998 and to its new campus on 6 October 2003.

Pedigreed population of Khaki Campbell, White Pekin and Kuzi ducks were maintained. Two promising egg type crosses using Khaki Campbell and Kuzi ducks being produced with higher number

for its evaluation in the farm and field. These two crosses produced more than 280 eggs under intensive system of rearing. Assessed and characterized Kuttanad (Chemballi ducks) under farm conditions in Odisha. Survey and recording of morphological characters and production performance of Kudu duck of Mayurbhanj district.

Low protein diets by balancing critical amino acids in White Pekin ducks developed. Azolla based diet for duck was developed to improve production performance. Composite diets (azolla, moringa, broken rice, earthworm meal, eggshell) for ducks was developed to enhance production and to lower feed cost. Alternative feed ingredients like cassava, wheat, or broken rice can effectively replace maize/wheat in duck diets for economical meat and egg production. A prototype "Duck Feeder-cum-Drinker" developed to minimizing feed loss and effective space utilization. "Dry sand" as duck house litter material is recommended. Intensive duck production in cages is standardized.

## AICRP on Poultry Breeding

The AICRP on Poultry Breeding was started during IV plan and has made significant contribution in the development of poultry sector over the years. Seven promising varieties of chicken were released for commercial exploitation. Rural component of the project was added during XI plan with two centres and strengthened in XII plan by adding four more centres. The AICRP on poultry breeding was completely re-oriented towards rural poultry from 2014–15 with all 12 centres to develop location-specific rural chicken varieties using native germplasm. The Directorate expanded further with the introduction of the Poultry Seed Project during XI plan with six centres. It was strengthened with five new centres from 2014–15 and three centres from 2017–18. During 2023-24, 12 centres of Poultry Seed Project was merged with AICRP on PB.

The major objective of AICRP on Poultry Breeding was to develop high yielding chicken varieties for commercial and rural poultry farming and to accomplish two major social obligations viz. minimizing the curse of the protein malnutrition and to ensure the supplemental income from poultry rearing / farming, thereby improving the economic status of mainly poor and landless farmers, weaker sections of the society. In addition, the adoption of technology by the target people will generate local and self-employment, restrict migration to the urban areas, develop cooperative network and better marketing, and encourage women empowerment. Developed six location specific improved rural chicken varieties along with their package of practices (Pratapdhan, Narmadanidhi, Kamrupa, Jharsim, Himsamridhi, Tokbari).

## Presently the centres are operational at

1. Kamadhenu University, Anand
2. Kerala Veterinary and Animal Science University, Mannuthy
3. Karnataka Veterinary, Animal and Fishery Sciences University, Bangalore
4. ICAR-Central Avian Research Institute, Izatnagar
5. Guru Angad Dev Veterinary and Animal Science University, Ludhiana
6. Nanaji Deshmukh Veterinary Science University, Jabalpur
7. Birsa Agricultural University, Ranchi

8. Maharana Pratap University of Agriculture & Technology, Udaipur
9. CSK Himachal Pradesh Krishi Viswavidyalaya, Palampur
10. Assam Agricultural University, Guwahati
11. Bihar Animal Sciences University, Patna
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13. Regional Centre, ICAR Research complex for NEH Region, Gangtok
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20. Chhathisgarh Kamadhenu Viswa Vidyalaya,Durg, Chatishgarhh
21. Krishi Vignan Kendra, Leh, SKUAST-K
22. ICAR-DPR, Regional Station, Bhubaneswar
23. GB Pant University of Agriculture and Technology, Pantnagar (Non Funded)

# Indian Poultry Science Association (IPSA)

The **Indian Poultry Science Association (IPSA)** was established in **March 1965** during the Poultry Research Workers' Conference at Pune, Maharashtra, with well-defined objectives aimed at promoting poultry development and strengthening the knowledge base in poultry science. It is a registered body under the Registrar of Societies, Bareilly, Uttar Pradesh, India (Registration No. 875/1989-90). IPSA is actively engaged in the **promotion and welfare of the poultry sector**, striving for the overall betterment of the profession by making it **socially attractive, environmentally responsible, and economically viable**. At present, IPSA has a membership of **over 1800**.

The Association comprises a diverse range of stakeholders, including:

1. Poultry science research, education, and training institutions
2. Public and private organizations
3. Commercial enterprises involved in poultry and allied sectors such as egg and meat processing, feed milling, compound feed manufacturing, health care and pharmaceutical products, poultry equipment production, hatcheries, and large-scale poultry production
4. Individuals engaged in small-scale poultry keeping
5. Scientists, professionals, researchers, and students

**Objectives of IPSA**

1. Advancement of knowledge in Poultry Science
2. Promotion of poultry development activities in the country,
3. Publication of a scientific journal,
4. Coordination of the activities of poultry research workers through technical meetings/ discussions on important topics and presentation of research work in all branches of poultry science, and
5. Encouragement of teaching, scientific research, practical experimentation, the collection and publication of statistics, the study of the economics of poultry business and study into the problems of production and marketing

**Management of the IPSA**

The IPSA is administered by a group of professionals who are both elected by the General Body (GB) and/or nominated by the President. The office bearers of the Executive Committee (EC) serve the Association as honorary members. The EC is helped by the members through counselling on betterment of the Association's activities. For dealing with regional issues, Local Chapters (LC) of IPSA can also be formed. The association has provided a common platform for exchange of ideas amongst the scientist, industry-man, students and entrepreneurs engaged in poultry research, teaching, production and extension activities in the country. It has also sent a noble trend of recognizing and honoring the poultry personalities including scientist, industrialists, administrators and the journalists who contributed significantly towards the success of poultry farming in India.

The Association recognizes and encourages outstanding contributions in the field of poultry science through a range of **awards, honours, and fellowships**. These distinctions highlight excellence in research, innovation, and professional service. The major awards instituted by IPSA include:

1. Ayurvet Award
2. Kerala Chapter Award
3. Dr. P. K. Pani Award
4. Avitech and Young Scientist Award
5. Dr. P. Kothandaraman Memorial Award
6. IPSA Dr. D. Choudhury Award for Best Doctoral Dissertation
7. IPSA Andhra Pradesh Chapter Award for Best M.V.Sc. Dissertation
8. Life Time Achievement Award

In addition, the Association confers **IPSA Fellowship** and other honours to distinguished professionals who have contributed significantly to the growth and success of the Indian poultry sector.

**Indian Journal of Poultry Science (IJPS)**

The Association's journal "The Indian Journal of Poultry Science" is the mouthpiece of the association in furthering its efforts to disseminating scientific and technological advances made in different branches of the Poultry Science discipline. The journal has received world acceptance and is being subscribed by several national and international institutions. From July 2024, IJPS has translated into digital and started publishing online in collaboration with ICAR-Directorate of Knowledge Management in Agriculture, New Delhi. *It is mandatory to register with IJPS both as reader and author to submit manuscript.* Indian Journal of Poultry Science levies a minimal processing fee of Rs. 1000/- upon acceptance of the manuscript.

Through the organization of **seminars, symposia, and technical meetings**, IPSA has played a vital role in bringing together scientists, industry professionals, and poultry farmers for the dissemination of the latest developments in poultry science. Over the years, the Association has successfully conducted **39 national symposia and conferences**, each focusing on key themes related to poultry production and human welfare across various regions of the country.

The **40th Annual Conference and National Symposium** in this series is being organized by the **ICAR–Directorate of Poultry Research, Rajendranagar, Hyderabad**, on the theme: **"Flock to the Future: Embracing Technology, Innovation, Entrepreneurship and Sustainability in Poultry Production for Protein Security in Viksit Bharat"**. to be held from **9th to 11th December 2025**.

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# IPSACON 2025
# 40th Annual Conference and National Symposium of Indian Poultry Science Association
## 9 - 11 December 2025

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# IPSACON 2025

## 40th Annual Conference and National Symposium of Indian Poultry Science Association

**9 - 11 December 2025**

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# Keynote Papers

KP-01

# Poultry: Purveyor of Protein Security in Viksit Bharat 2047

**Tarun Shridhar**
Director General, Indian Chamber of Food and Agriculture and former Secretary, Ministry of Fisheries, Animal Husbandry and Dairying, Government of India

"If you think in terms of a year, plant a seed; if in terms of ten years, plant trees; if in terms of 100 years, teach the people", advises the wisdom of Confucius. Our people, on completion of 100 years of our nation's independence, are slowly but surely progressing to the vision of a Viksit Bharat (Developed India) by 2047. This represents India's transformative ambition to achieve developed nation status by the 100th anniversary of its independence. It is a national aspiration to foster a self-reliant and prosperous economy, characterized by comprehensive advancements across multiple societal and economic dimensions. The foundational framework for this vision, following the wisdom of Confucius, rests upon four strategic sets of people: Yuva (Youth), Garib (Poor), Mahila (Women), and Kisan (Farmers), emphasizing inclusive growth as a core principle.

The overarching goals of Viksit Bharat 2047 extend beyond mere economic expansion to encompass social equity, global competitiveness, environmental sustainability, technology, and transparent governance. Specific objectives articulated within this vision include the eradication of poverty, ensuring universal access to high-quality education and healthcare, achieving 100% skilled labor with meaningful employment opportunities, and significantly increasing women's participation in economic activities. A crucial objective for Indian farmers is to transform the country into the food basket of the world. Economically, India aims for its Gross Domestic Product (GDP) to surpass US$ 7 trillion by 2030 and reach an impressive US$ 34.7 trillion by 2047, with per capita income projected to reach US$ 21,000 within the same timeframe. The anticipated shifts in sectoral contributions to GDP by 2047 indicate a structural transformation, with agriculture's share projected to decrease to 12%, while the industrial sector is expected to reach 34%, manufacturing 25%, and services remaining stable at approximately 54%.

The projected reduction in agriculture's contribution to GDP to 12% might initially appear counterintuitive for a nation that places farmer welfare at the core of its development strategy. However, this trend is characteristic of developed economies, where economic activity naturally shifts from primary sectors like agriculture towards higher value industrial and service sectors. For the 'Kisan' pillar to thrive amidst this structural change, the focus must move beyond simply the quantitative share of agricultural output to a qualitative enhancement of the sector. This implies a significant increase in productivity per farmer, a robust emphasis on value addition within the agricultural sector, and a strategic diversification of rural incomes beyond traditional crop cultivation. Industries allied to agriculture, such as poultry farming, are therefore vital. They offer higher-value products like meat and eggs, require less arable land compared to traditional crops, and foster entrepreneurship in rural communities. Agriculture and its allied sectors are recognized as critical enablers for achieving the vision of Viksit Bharat. Let us understand how and where the poultry sector gets positioned in our national vision and ambition?

The poultry industry is recognised as a dynamic pillar of the global agricultural economy, providing an indispensable and often preferred source of protein for billions worldwide. Its remarkable growth trajectory and inherent adaptability underscore its central role in addressing global food security imperatives. Among animal proteins, poultry distinguishes itself through its superior production efficiency, rapid growth cycle, and competitive pricing, rendering it an accessible and cost-effective dietary staple across a wide spectrum of income levels. A notable characteristic of the poultry sector is its demonstrated ability to maintain positive growth and recover swiftly, even amidst significant global disruptions such as the COVID-19 pandemic and widespread Highly Pathogenic Avian Influenza (HPAI) outbreaks. For instance, broiler production sustained positive annual growth through both the pandemic and the avian influenza outbreak, a resilience not uniformly observed in other allied sectors. This consistent pattern of adaptability and recovery positions poultry as a relatively more reliable protein source in an increasingly volatile global environment. This inherent strength suggests that even when the industry encounters future challenges, its structural attribute of quick turnaround time and capacity to absorb shocks shall ensure its continued upward trajectory, making it a secure option for long-term investment and policy focus compared to other agricultural sectors.

There is a sustained increase in global demand for animal protein, with poultry consistently favored for its versatility, perceived health benefits, and its comparatively lower carbon footprint when juxtaposed with red meat. Growing health consciousness and changing dietary preferences are actively boosting poultry consumption, leading to a broader societal shift towards protein-rich diets. The global poultry sector is on a clear path of expansion, with significant increases projected in both production and consumption. Global poultry meat consumption is projected to reach 160 million metric tons (MT) retail weight equivalent by 2033, a volume expected to account for half of the total additional meat consumed during that period. This highlights poultry's increasing share of the overall meat market. Annual global poultry production is forecast to increase by 15% over the projection period, reaching 162 million tonnes by 2034. This impressive growth is largely attributed to increasing demand and the comparatively lower initial costs associated with poultry production relative to other meats.

Focusing specifically on chicken meat, the global market volume is projected to reach 133 million tonnes by the end of 2035, with its market value anticipated to reach $286.3 billion, reflecting a Compound Annual Growth Rate (CAGR) of +0.8% in volume and +2.0% in value from 2024 to 2035. The broader "Poultry Meat Market," which includes chicken, turkey, and duck, is expected to grow from an estimated $327.57 billion in 2024 to $458.60 billion by 2034, demonstrating a CAGR of 3.4% during this period. Overall, poultry meat consumption is estimated to grow by 15% in the next decade (to 2032), according to projections from FAO and OECD. The most significant growth is expected in Asia, Africa, and Latin America, fueled by burgeoning populations, rapid urbanization, and rising disposable incomes. These regions are set to play a pivotal role in shaping the global agricultural landscape, with India projected to surpass China as a leading player in agricultural markets.

The Indian poultry sector stands as one of the most dynamic and rapidly expanding segments within the nation's agricultural landscape. Its growth trajectory reflects a significant transformation from traditional backyard farming to a sophisticated commercial enterprise. This evolution has propelled India into a prominent position on the global stage.

India currently ranks as the 2nd largest egg producer globally, with an impressive 142.77 billion eggs produced during 2023-24. About 85% of these eggs are the output of commercial poultry, signifying a progressive evolution of a traditional backyard activity to an industrial one. In poultry meat production, India holds the 5th position worldwide, with an output of over 5 million tonnes in 2023-24, contributing nearly half of the country's total meat production. Over the past decade, the sector has demonstrated robust expansion, growing at a healthy rate of 8-10% annually.

The consistent and rapid expansion of the Indian poultry industry, as evidenced by the significant increase in egg production and its improving global ranking, underscores a highly dynamic and responsive sector. This continuous scaling up is not merely about achieving larger production volumes; it signifies the industry's capacity for adaptation and modernization. Such robust growth positions India not just as a major producer but as a potential global leader in poultry, directly supporting Viksit Bharat's overarching goal of enhancing global competitiveness and establishing India as a key global economic player by 2047.

The poultry sector's economic footprint extends significantly across the Indian economy. It is a major employment generator, providing directly and indirectly over 4 million job opportunities, predominantly in rural areas. This substantial labor absorption capacity is particularly vital for the 'Garib' and 'Kisan' pillars of Viksit Bharat, as it translates into direct income generation and improved livelihoods for a large segment of the population, fostering rural prosperity and reducing inequality.

In terms of economic output, the poultry industry contributed approximately 1% to the national GDP and 14% to the livestock GDP. While the 1% contribution to the national GDP might appear modest in the context of India's ambitious target of a US$ 34.7 trillion economy by 2047, the sector's substantial employment generation and its significant share within the broader livestock economy highlight its profound impact on rural livelihoods. Given that 95% of livestock farmers are concentrated in rural India, the sector's ability to create millions of jobs and generate income directly contributes to the social equity objectives of Viksit Bharat, supporting the upliftment of marginalized communities and fostering inclusive growth. The economic benefits extend beyond direct farming to the entire value chain, including feed production, processing, transportation, and retail, creating a multiplier effect that stimulates broader rural development.

Protein malnutrition is a pervasive and silent crisis across India, affecting millions. Over 80% of the population fails to meet their daily protein requirements, with a staggering 73% identified as protein deficient. The average Indian consumes only 0.6 grams of protein per kilogram of body weight daily, significantly below the Indian Council of Medical Research (ICMR) recommendation of 0.8 to 1 gram per kilogram. This deficiency has adverse consequences, including stunted growth and impaired cognitive development in children, and reduced muscle mass, weakened immunity, and decreased productivity in adults. Poultry products, particularly eggs and chicken, are a solution to this nutritional challenge. They are among the most affordable and readily available sources of high quality protein containing all essential amino acids not found in many plant-based foods, along with vital vitamins, minerals, and beneficial fats. Their versatility and ease of preparation make them suitable for diverse dietary preferences across various income groups.

The critical role of poultry in improving public health and human capital is evident. Increasing the per capita consumption of poultry products, which currently lags significantly behind recommended levels, can directly address widespread protein deficiency. Per capita egg availability has risen to 103 eggs per year; though impressive it is still below the recommendation of the National Institution of Nutrition which advises a consumption of 180 eggs per person per year. The per capita annual consumption of poultry meat stands at about 3.4 kg which is considerably below the recommended 11 kg. This substantial gap highlights a strategic opportunity for intervention. Promoting poultry consumption through targeted awareness campaigns and integrating eggs and chicken into government nutrition programs, such as mid-day meals in schools, can significantly improve nutritional outcomes, especially for vulnerable populations like children. This investment in a healthier, more productive citizenry is foundational to achieving the broader economic and social development goals of Viksit Bharat.

While the Indian poultry sector is poised for significant contributions to Viksit Bharat 2047, it faces several critical challenges that necessitate strategic interventions. One of the most significant challenges confronting the Indian poultry industry is the volatility and high cost of feed. Feed expenses constitute a substantial 65-70% of total production costs, making the sector's profitability highly sensitive to price fluctuations in key ingredients. A major contributing factor to this challenge is the rising demand for maize, a primary feed ingredient, which is increasingly being diverted towards ethanol production. This creates a systemic conflict between national priorities of energy production and nutritional security, leading to shortages and pressure on maize prices. Stagnant soybean yields further exacerbate the feed challenges. This situation threatens the sector's consistent growth trajectory and its ability to contribute to Viksit Bharat's economic goals. Strong policy interventions regarding imports of genetically modified (GM) maize and soybean meal, and incentivizing domestic production of alternative, cost-effective feed ingredients are the need of the hour.

The poultry sector is highly susceptible to disease outbreaks, such as Avian Influenza, which can decimate entire flocks overnight, leading to substantial economic losses for farmers and significant disruptions in supply chains. The challenge is compounded by inadequate disease surveillance systems. Effective disease surveillance and control are paramount for maintaining supply stability, preventing economic losses, and, crucially, for growth in trade. International trade in poultry products is sensitive to a country's disease status. Therefore, making effective biosecurity measures and keeping the poultry disease-free is essential for India to realize its export potential and hence achieve its global standing as a Viksit Bharat.

A significant structural inefficiency in the Indian poultry market is the dominance of wet markets, where over 90% of chicken is sold as live birds for on-site slaughter. While culturally ingrained, this traditional model presents numerous challenges, including hygiene concerns, operational inefficiencies, and high price volatility for farmers. This limits the industry's ability to transition towards a more hygienic, efficient, and standardized processed product market. Furthermore, limited demand for frozen products, coupled with poor and high-cost transport infrastructure and unreliable cold chain facilities, severely impedes efficient distribution and value realization. These gaps hinder product diversification and wider market penetration for processed poultry. Addressing these inefficiencies through strategic investments in modern processing units, robust cold chain logistics, and promoting a

shift towards packaged products will not only improve profitability and reduce waste but also enhance food safety and consumer trust, aligning with Viksit Bharat's goals of industrial modernization and improved public health outcomes.

Vertical integration, encompassing the entire poultry value chain from breeding and feed milling to processing and marketing, has proven to be a key driver of growth in the Indian poultry sector. This model has significantly increased production efficiency, reduced marketing margins, and consequently lowered consumer prices. This approach allows for greater control over the entire supply chain, effectively mitigating risks such as feed price volatility and disease outbreaks through coordinated management and quality control. For Viksit Bharat, this means not just increased production but more stable and predictable growth, which is crucial for attracting further investment and ensuring a consistent supply to meet the nation's growing demand. It also facilitates the widespread adoption of technology and quality control measures, leading to higher quality products and better consumer prices, thereby contributing to overall economic stability and public welfare.

The current low rate of value-added processing, with only 8-10% of poultry meat undergoing further processing, presents a substantial untapped opportunity for the sector to move up the economic ladder. The processed poultry segment is already witnessing significant innovation and product diversification, with a growing array of products such as sausages, nuggets, and ready-to-cook meals catering to evolving consumer preferences for convenience and variety. Shifting from raw commodities to processed, packaged, and branded products generates higher revenue, creates more skilled employment opportunities, and caters to the increasing demands of urban consumers. Concurrently, India is emerging as an exporter of chicken meat, particularly to the Middle East and Southeast Asia. Leveraging India's competitive production costs and capitalizing on the rising global demand for animal protein allows the sector to significantly boost its export earnings. Government support for export-oriented policies is crucial in realizing this potential, contributing directly to India's global competitiveness and trade objectives under Viksit Bharat.

The Indian poultry sector stands as an indispensable force in achieving the multifaceted objectives of Viksit Bharat 2047. Its role extends across the core pillars of national development, demonstrating a profound and far-reaching impact. The sector is a powerful engine for economic growth, generating millions of jobs and significantly boosting rural incomes, thereby directly addressing the welfare of 'Kisan' (Farmers) and alleviating the challenges faced by the 'Garib' (Poor). Furthermore, it serves as a vital source of affordable, high-quality protein, crucial for combating widespread malnutrition and improving public health outcomes, which is fundamental to enhancing the nation's human capital for a developed India.

The unique structure of the poultry industry, particularly with strong women's participation in backyard farming and through the support of Farmer Producer Organizations (FPOs), makes it a key driver of women's empowerment and broader social equity, aligning seamlessly with the 'Mahila' (Women) pillar. The industry's proactive embrace of advanced technologies, ranging from genetic engineering and precision farming to automation and blockchain, positions it at the forefront of agricultural modernization and innovation, essential for India's global competitiveness. The comprehensive impact of poultry across economic growth, poverty alleviation, nutritional security, women's empowerment,

technological advancement, and environmental sustainability illustrates how this single industry, when strategically nurtured, can generate multi-faceted benefits across society and the economy. This embodies the inclusive and progressive spirit of the holistic development model envisioned for Viksit Bharat 2047.

Strategic imperatives for the future include continued investment in value-added processing to cater to evolving consumer demands and generate higher economic returns. Aggressive pursuit of global export markets, leveraging India's competitive advantages, will enhance the nation's global standing. Deepening technological integration across the entire value chain will drive further productivity gains, improve product quality, and build resilience. Furthermore, strengthening Farmer Producer Organizations (FPOs) and promoting rural entrepreneurship will ensure that the benefits of growth are equitably distributed, fostering broad-based rural prosperity. These challenges and opportunities are not isolated but interconnected, requiring a synergistic approach to policy and investment. For instance, addressing feed costs directly impacts profitability, which in turn influences investment in technology and value addition. Similarly, robust disease management is crucial for both domestic supply stability and export potential. This highlights that sustained growth towards Viksit Bharat hinges on recognizing these interdependencies and implementing integrated strategies that leverage opportunities to mitigate challenges across the entire poultry value chain. Continued collaboration between government, industry stakeholders, and research institutions will be paramount to navigate future complexities and capitalize on emerging opportunities, positioning India's poultry sector as a global leader and a cornerstone of Viksit Bharat by 2047.

"What separates developing countries from developed countries is as much a gap in knowledge as a gap in resources" states Joseph Stiglitz, the renowned economist. We are truly destined to bridge this gap shortly, and poultry's contribution would be pivotal.

KP-02

# New frontiers in poultry nutrition technologies for protein security

**D.V.R. Prakash Rao**
President, National Academy of Veterinary Sciences (India), New Delhi,
Chairman and Managing Director, Prakash Foods & Feed Mills Pvt Ltd, Chennai.

Distinguished Scientists, My Dear Colleagues, Ladies & Gentlemen. GOOD MORNING, NAMASHKAR. It is a great honour and privilege for me to address this distinguished gathering on a subject at the very core of our national & global food agenda – How frontier advances in poultry nutrition can contribute to achieving protein security in a sustainable and scientifically robust manner.

India's poultry sector has undergone a paradigm shift from a backyard activity into a most dynamic segments of our livestock economy. Currently this sector contributes over 10 million tons of meat annually with a percapita availability of 103 eggs per person per year - A remarkable rise in the last two decades. The poultry meat and eggs contributes to more than 45% of the country's animal protein supply. These achievements are not merely commercial but are nutritional, social and developmental directly aligned with the vision of ensuring affordable and safe protein for every Indian household.

The Industry is confronted with complex set of challenges as the eggs and meat production is expanding such as raw material availability, the demand to reduce the sector's environmental foot print, mitigate antimicrobial resistance and enhance animal welfare and sustainability. The poultry nutrition must evolve beyond classical feed formulation into a multi-disciplinary science, integrating biology, data analytics and circular economy principles in order to sustain these multifactorial issues.

There are five major frontiers that can redefine the science of poultry nutrition to the modern day requirement. The first frontier is precision nutrition and precision feeding. The second frontier lies in molecular nutrition (ie) nutrigenomics transcriptomics and metabolomics. The third frontier is the diversification of protein sources especially recycled animal offal, single – cell proteins, insect meals and algal biomass. The fourth frontier concerns gut health modulation and antibiotic alternatives. The fifth frontier is digitalization and artificial intelligence in feed formulation and farm management.

Beyond these five frontiers, sustainability and circularity cuts across all dimensions of nutrition science. The poultry sector must quantify not only productivity but also environmental performance (ie) carbon foot print per kg of meet or eggs, water use efficiency, nutrition excretion and land use intensity. The life cycle assessment tools are becoming essential compliments to nutritional formulation software. We can design diets that minimize green house gas emissions without compromising productivity by integrating environmental coefficients of feed ingredients into the formulation.

The processed byproducts (ie) usage of feather hydrolysates, spent grains or oil cake extractions through enzymatic or microbial upgrading can further close the nutrient loops. These circular approaches contribute to both cost reduction and sustainability metrics, aligning poultry production with the broader national goals of resource efficiency and net zero commitments.

The implications of these frontiers on India's poultry science community are profound. We have to

reorient the research towards integrative experimentation combining precision feeding, molecular biology and systems modelling. The collaboration between academia, feed manufacturers, biotechnology firms and digital innovators is essential. The regulatory bodies must facilitate safe evaluation and approval of novel feed ingredients while academic institutions should strengthen capacity building in feed analytics, metabolomics and data science.

Ultimately the protein security is not merely a production target but is a scientific responsibility. Poultry are the most resource efficient convertor of feed into high quality animal protein and hence holds a strategic role in India's nutrition future. We can ensure that our growth is not only quantitative but also sustainable, resilient and technologically advanced by embracing these scientific frontiers.

Looking forward, disease – nutrition interactions will define the next phase of poultry health management. Emerging threats such as heat stress induced immunosuppression, mycotoxin exposure and the re-surgence of enteric pathogens in antibiotic free systems demand integrated nutritional counter strategies. Future feed formulations will likely incorporate functional ingredients such as immunomodulatory peptides, nucleotides, omega 3 fatty acids and probiotics to prime immune resilience rather than merely prevent deficiency. As disease ecology becomes more complex under intensified production, nutrition will serve as the scientific bridge between productivity and health security in poultry systems.

The interplay between nutrition and disease resistance is emerging as one of the most critical frontiers in poultry science. The nutritional status profoundly modulates the immune competence of birds, influencing both innate and adaptive responses. Thus the modern nutritional immunology recognizes that the gut is not merely a digestive organ but an immunological interface where the metabolites regulate cytokine expression, microbial homeostasis and a systemic inflammation.

I once again thank the organizers for inviting me as a key note speaker on this lively subject.

# Lead Papers

LP-01

# Advances in computational genetics with special reference to poultry

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Animal genetic evaluation is an essential process in livestock industry for selecting the best individuals based on their true genetic value. These selected individuals are usually a portion from far-right end of normal distribution for the trait when directional selection for the trait of interest is practiced. Here the question is how best is the selection process? Do we really look at the genetic values? How best is the approximation?

***Selecting for economically important traits***

The selection program works with a few known parameters such as heritability of the trait, generation interval, intensity of the selection of parents from the population. These parameters help us to predict the response to selection after one generation. The *"Breeder's equation*" (Lush, 1943) defines how the genetic improvement takes place in the breeding program. The factors affecting traditional genetic improvement programs are many. Given the principles of animal breeding, the response to selection in any selection experiment is bound to be influenced by factors below.

$$\mathbf{R = h^2 S}$$

where, **R** is response to selection, $\mathbf{h^2}$ is heritability of a trait and **S** is the selection differential i.e. superiority of the parents to their contemporaries.

The rate at which males and females are selected to make them parents of next generation is also different. Thus, the response to selection is further expanded to include these factors (Falconer and Mackay1996)

$$\boldsymbol{R = \frac{i_m + i_f}{L_m + L_f} * \sigma_a * r}$$

where, intensities (i) and generation intervals (L) can be attributed to the male and females in the population separately. $\sigma_a$ is the estimate for additive genetic standard deviation and r is accuracy of selection.

India boasts one of the world's largest and most varied poultry industries, with over 851 million chickens supporting rural economies, nutritional security, and a multi-trillion-rupee market. The sector is dual-structured: commercial operations dominate ~90% of egg production and most broilers using imported high-yielding breeds, while indigenous (desi) chickens contribute ~11.5% of eggs in backyard systems, valued for disease resistance, thermotolerance, and premium meat/egg quality. Traditional genetic selection through mainly pedigree has already helped a lot for poultry industry due to high selection intensity and better selection differential. However, implementation of genomic selection is a new hope for much aggressive gains.

Genomic selection (Meuwissen et al. 2001) has special advantages for sex limited and lately expressed traits. Genomic selection works on the principle that every single nucleotide polymorphism (SNP) is in linkage disequilibrium (LD) with associated quantitative trait locus (QTL) across the genome,

and maximum genetic variance is captured through this LD. This helps in prediction of genomically estimated breeding values (GEBV) for all the individuals, with higher accuracy and at early age. Single-Step GBLUP was evolved as a new method, where the genomic relationship from recently genotyped animals was inferred to the non-genotyped animals in the pedigree using a realized relationship matrix **H** (Legarra et al. 2009).

The Single-Step GBLUP had several advantages, one of the most important advantages was, it brought best from both the worlds of pedigree and genomics to the same platform. Several modifications to the SSGBLUP lead to obtaining higher accuracy as well as unbiased estimates of breeding values. Usually, tuning for **G** and $\mathbf{A}_{22}$ have been very successful approach. NRM based BLUP builds up inbreeding, which was not accounted for in the BLUP. Not accounting for inbreeding in NRM, while constructing $\mathbf{H}^{-1}$ lead to biased estimates of breeding values. Gowane et al. (2019b) reported SSGBLUP with inbreeding to result in unbiased and more accurate estimates of breeding values in selectively genotyped populations.

***Genomic Selection (GS) and its Implementation in Poultry***

GS is routinely applied in poultry breeding, from experimental trials to commercial settings, covering tool development, cost estimation, and deployment. Experimental data confirm genomic information boosts estimated breeding value (EBV) accuracy, yielding superior selection responses over pedigree methods (Wolc et al., 2016). However, according to Mitszal et al. (2013), "Methodology for genomic selection in a commercial situation is dependent on attention to detail, using the mature methodology, and knowledge of issues of genomic selection specific to a given population."

It was observed that the genomic selection can double annual progress vs. BLUP; 80–120% in broiler growth, 60–90% in layer persistency, 50–100% in feed efficiency. Layer intervals shorten from ~1 year (female egg phenotyping) to 6–7 months at puberty; halving female intervals is impractical commercially but promising for males (Wolc et al., 2015). It especially excels for sex-limited, hard/expensive/late traits (e.g., rooster egg production); captures Mendelian sampling for within-family selection (Wolc et al., 2016). Opportunities to reduce generation intervals are, however, limited, in particular for broiler breeding programs. The genomic prediction accuracy decays over time. This particularly erodes over time/generations (Habier et al., 2007; Wolc et al., 2011) and hence needs frequent retraining.

Under Indian Context, genomic selection can adapt global tools via ssGBLUP and Bayesian models for GEBVs (>0.75 accuracy for low-heritability traits); it can expand to crossbreds/natives with low-density SNPs/imputation. SNP chips such as Axiom_Kukkut (high-density, 16 natives + exotics) and Indichick (97% breed ID) can prove to be useful for tracking the true genetic variation in Indian poultry industry.

***Real challenges for implementation of genomic selection in Indian context***

In the developing world, we face certain challenges to fully adopt this developed model of genomic selection. The challenges are at the level of reference creation, statistical model development that suits local needs and futuristic needs:

a. ***Selection of the candidates to form the reference***

The reference population needs large number of animals genotyped. However, genotyping cost has been a great hurdle in making this possible, along with costs of recording accurate phenotype (Gowane et al. 2019a). In the systematic breeding program, where phenotypes are recorded properly, and there is a choice of which animals to be genotyped, a significant bias can be introduced. Selective genotyping that favours inclusion of most of the diverse genetic representation in the reference results in most accurate and unbiased predictions. In our study (Gowane et al. 2019b), we observed that, in a typical animal breeding program, where it is too expensive to genotype all animals, it would be appropriate to genotype phenotypically contrasting selection candidates and use a Single-Step approach to obtain accurate and unbiased prediction of GEBV. We could show 0.68 accuracy using ssGBLUP (20% animals genotyped) as against 0.45 from PBLUP. However this demanded correction of the $\mathbf{A}^{-1}$ taking inbreeding into account (Garcia-Baccino et al., 2017), which resulted in unbiased estimates.

b. ***Holes in the pedigree and implementation of single-step procedures***

Poor data recording is another great challenge with incomplete pedigrees or holes in the pedigree commonly observed. In such situation, again modelling for the genomic selection is difficult. This requires too much of emphasis on correct modelling and inclusion of all the causal factors in the model. Use of only genomic models (GBLUP/Bayes alphabets) can be handy, however does not yield better accuracy and are usually biased. We could show that, better accuracies and less bias of prediction using single-step models can be obtained even if truncated pedigrees extending to hardly 1 generation in past are available (Gowane et al. 2022). This study showed that, in shallow pedigree scenario, with all female reference (missing 4 distant generations) accuracy can be obtained as high as 0.50 ± 0.02; with dispersion of 0.96 ± 0.02.

***Future for computational genomics***

Computational genetics has progressed rapidly over the past two decades, particularly with the advent of the genomic selection era, emerging as the cornerstone of modern poultry improvement. By harnessing vast genomic datasets and advanced algorithms, the field delivers unprecedented gains in accuracy, efficiency, and genetic progress, compressing decades of traditional advancement into single breeding cycles. How computational genetics drives progress is seen through High-throughput platforms-SNP arrays >600K markers, sequencing, imputation-generate terabytes from million-bird populations, powering GS. However, in future we will probably end up with large data dimensionality issues in commercial birds.

***Genomic prediction for increased dimensionality of genomic information***

Although right now, the number of genotyped birds is not very large in Indian conditions, however in near future, these numbers will be exploding. This is sure due to significantly reduced price of genotyping. Use of accurate genetic parameters is very essential to obtain unbiased and accurate breeding values and also to predict the accurate selection response. If wrong estimates are plugged, we may end up with vague and unreliable estimates.

Over the period of time, genotyping cost is decreasing and hence it is expected that the number of genotyped animals will be increasing at faster rate per breed. As of now, HF crossbred and other

populations with genotyped animals in RGM have already crossed several thousands. For the available method of prediction of breeding value, it is difficult to obtain $H^{-1}$ if number of animals is too large (>30000). In such scenario, alternate method was developed to obtain inverse of core and non-core animals in the relationship using algorithm for proven and young (APY) as given by Mitszal (2014). This approach derives a number of animals from the whole animals as core depending upon effective number of chromosome segments in the data (Me). Core is close to the dimensionality of **G** or number of eigenvalues able to explain 99% variance of the **G** matrix (Pocrnic et al. 2016). With the use of algorithm for proven and young (Misztal et al. 2016) inverse of the relationship matrix ($\mathbf{G}^{-1}_{APY}$) can be approximated by a sparse matrix for populations with small effective population size. This approach works practically very well for obtaining breeding values for the genotyped animals with literally aby possible large number. As of now, Holstein cattle has nearly 8 million animals genotyped, and APY can be efficiently used to obtain the genomic estimates of breeding values.

$$\boldsymbol{G}^{-1}_{APY} = \begin{bmatrix} \boldsymbol{G}^{-1}_{cc} & 0 \\ 0 & 0 \end{bmatrix} + \begin{bmatrix} -\boldsymbol{G}^{-1}_{cc}\boldsymbol{G}_{cn} \\ \boldsymbol{I} \end{bmatrix} \boldsymbol{M}^{-1}_{nn}(-\boldsymbol{G}_{nc}\boldsymbol{G}^{-1}_{cc} \quad \boldsymbol{I})$$

Where, $\boldsymbol{M}_{nn}$ is $= diag\{g_{ii} - g_{ic}\boldsymbol{G}^{-1}_{cc}g_{ci}\}$

\In large genotyped population, obtaining reliable estimates of genetic parameters is a big challenge, as it is impossible to use traditionally available tools such as genomic REML or Gibbs sampling with increased dimensionality of genomic data. Although REML (Patterson and Thomson, 1971) and Bayesian via Gibbs sampling (Gianola and Fernando, 1986) have good theoretical properties but with genomic information, the mixed model equations are not sparse as genomic components create a dense subblock (Misztal et al., 2021). For large data, relationship matrix for genotyped animals is too dense and hence sparse representations such as $\mathbf{G}^{-1}_{APY}$ also fails. Misztal and Gowane (2025) developed the method to estimate heritability and genetic correlations using theoretical (Daetwyler et al. 2008) and realized accuracy (Legarra et al. 2008). This method is called as "**Genetic Parameters via predictivity**" or **GPP**. These approximations have prospects as the traditional methods fail to generate estimates for large scale genomic data. We could show that the GPP for a large data can finish one analysis of 1 million datasets within an hour. Recently developed tools (Misztal and Gowane 2025) showed that GPP approach works really well and matches with realized estimates of genetic parameters in the real data, e. g. foot score in Angus cattle (Trujano et al. 2025). The genetic parameters thus obtained can then be finally used in the BLUP for obtaining reliable estimates of breeding values. The newly developed formula for the heritability is:

$$\widehat{\boxtimes^2} = \frac{c^2 + \sqrt{c^4 + 4c^2 M_e/N}}{2}$$

Where, N is the number of animals in the reference group, 'c' is an estimate of predictivity, a correlation between adjusted phenotypes and estimated breeding values in the last generation (focal group) across each time slice, .  is the effective number of chromosome segments.

The genetic correlation between traits *i* and *j* can be estimated as

$$\widehat{\boxtimes^2} = \frac{c^2 + \sqrt{c^4 + 4c^2 M_e/N}}{2}$$

where, $acc_j$ is $c/h_j$

Poultry's unique advantages-large effective population sizes, short generation intervals (6–8 weeks in layers), and centralized nucleus breeding-amplify the impact of these computational tools and hence also a candidate for the use of the methods such as APY (algorithm for proven and young) and GPP.

## Conclusion

Poultry industry in India is at initial stage for implementation of the genomic selection method. Several challenges associated with the use of this technology can be handled with creation of reference populations which work in real life with optimal selection of candidates, use of single-step methodology, and updating the reference. The problem of large data dimensionality associated with genomics can also be handled with future ready methods such as APY and GPP. This essentially opens up a new ray of hope for faster genetic progress in commercial and non-commercial breeds of the poultry.

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LP-02

# Genome editing: An emerging tool for enhancing productivity in poultry

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**Abstract**

Genome editing has been an important tool to edit single or multiple genes at a time with the help of specific enzyme to regulate specific trait(s) of economic importance in human and animals. For improvement of egg production, editing negatively regulated gene controlling egg production may be one approach for rapid augmentation of egg production in chicken. In this study, we have edited inhibin alpha gene, which plays significant role to inhibit synthesis of FSH in the pituitary gland and consequently, affects follicular growth eventually required for initiating ovulation to release eggs in the infundibulum of the reproductive tract leading to laying of eggs in chicken. Editing inhibin alpha gene has been carried out with CRISPR/Cas in Nicobari Indian native chicken breed to analyse effect on egg production. Exon1 of the gene has been edited where substitution and deletion of nucleotides in the sgRNA corresponding sequences have been observed in the inhibin alpha gene. Consequently, amino acid substitution and frameshift mutations have been happened. Annual egg production was significantly higher by 95.3% in edited birds as compared to the control birds (250 vs 128 eggs). Internal egg quality parameters such as Haugh unit and yolk colour index was 19.8 and 17.5% higher, respectively in the edited birds as compared to the control hens. It is concluded that the editing of exon1 of inhibin alpha gene had significant effect on enhancing egg production in native Nacobari chicken.

**Key words:** Chicken, CRISPR/Cas, Egg production, Gene editing

## Introduction

Egg production in chicken is controlled by hypothalamus-pituitary-ovary axis of endocrine system where two important hormones follicle stimulating hormone (FSH) and luteinizing hormone (LH) play pivotal role. The FSH is essential for pubertal development and functions of the ovary. The FSH stimulates growth of ovarian follicles (Johnson 1986, McDonald 1989, Johnson 1997). As the follicle grows, more estrogen is released from the follicles. Estrogen stimulates surge in luteinizing hormone, which accelerate the ovulation process for release of eggs from the follicles. When the follicles grow, the cells of the follicles produce increasing amounts of estrogen and inhibin. The production of estrogen and inhibin is sensed by the hypothalamus and pituitary gland and consequently, there is less release of GnRH and FSH in the blood stream, which lowers further growth of immature follicles to mature ones. Follicular maturation is an essential step for ovulation through estrogen-LH pathway. Thus, inhibin plays significant role in reducing release of FSH in the blood and consequently, affecting follicular growth directly and ovulation process indirectly in chicken.

To enhance egg production, increasing level of FSH is immense important in chicken. Enhancing this hormone can be accomplished by many techniques of which editing FSH inhibitory genes may be one of the direct approaches to enhance level of FSH in chicken. In this context, editing one of the FSH

inhibitory genes, Inhibin alpha has been one important target. In this study, we considered editing inhibin alpha gene for minimizing its activity to enhance egg production by increasing serum FSH level in chicken (Ling *et al*. 1985). Chicken inhibin alpha-subunit (INHA) has an open reading frame of 990 nucleotides encoding 328 amino acids. This gene contains two exons viz. exon1 and exon2 of which the exon1 is 256 bp in length while the 2nd exon is of 734 bp.

Of the genome editing tools, earlier studies reported the use of Zinc Finger Nucleases and Transcription Activator Like Effector Nucleases for generating targeted mutagenesis/ genome editing but the drawback of these technologies is that they were based on "protein-DNA interactions", requiring enzyme engineering and precision of editing. As precision is dictated by DNA complementarity, the CRISPR/Cas technology has added its advantages for genome-editing in collation to customary ZFN and TALENs approaches (Cheng *et al*. 2019). Therefore, like in other livestock species, genome editing is expected to allow desired changes to be made in the genome of poultry species, though the reproductive biology of birds is very specific to achieve heritable edited traits (Bhattacharya *et al.* 2016, Bhattacharya *et al.* 2019, Prasad *et al.* 2022). In the present study, we have edited the exon 1 of the inhibin alpha gene and explore its effect on production traits in native chicken.

**Materials and methods**

**Experimental Animals:** Experiment was conducted in Nicobari native chicken maintained at the experimental farm of ICAR-Directorate of Poultry Research, Hyderabad, India. The whole study was approved by the Institute Animal Ethics Committee (IAEC), Institute Biosafety Committee (IBSC) of ICAR-Directorate of Poultry Research, Hyderabad, India and the Review Committee on Genetic Manipulation (RCGM), Dept. of Biotechnology, Govt. of India. All the guidelines of IAEC, IBSC and RCGM were followed while conducting the experiments.

sgRNA clones and transfer: The sgRNA molecules were designed from two exons of chicken Inhibin alpha gene with the Chop Chop software. Two exons were targeted where one sgRNA molecule each for each exon was designed. Both sense and antisense strands of each sgRNA molecules were cloned in ZsGreen1 vector.

Sperm mediated gene transfer method was followed. Exon1 sgRNAs zsGreen1 recombinant clones were used to transfect sperms, which were inseminated to hens and eggs were collected. Eggs were hatched. All healthy chicks were wing-banded with metal bands. On 7th week, birds were relocated at the battery brooder.

Blood samples were collected from all the birds of different treatment and control groups. Genomic DNA was isolated from all the blood samples and screened by PCR using specific primers. All the positive samples were subjected to Southern blotting and sequencing for re-confirmation.

**Traits:** Body weights of the birds of both edited and control groups were measured in electronic weighing balance on 15th week. Egg production of birds under treatment and control groups were recorded. Egg quality traits such as alubumin%, yolk%, shell%, albumin index, yolk index, Haugh unit, shell thickness, egg shape index and yolk colour index in egg analyzer.

**Hormone profile**: Hormones such as FSH, LH, progesterone and estrogen in serum samples of both edited and control birds at the age of 31 weeks were estimated following Chemiluminescence Immunoassay.

**Statistical analysis:** Effect of editing of inhibin alpha gene on egg production and quality, growth and and hormonal traits were analysed by GLM procedure with SPSS20.0 software. Duncan's multiple range test (DMRT) was performed to determine the effect of each group.

**Results and discussion**

**Gene edited chicks:** We transferred the sgRNA clones to the host genome through sperm mediated method. By PCR screening and sequencing, we obtained 3 edited birds. Sequencing results revealed that the edited birds were of heterozygous for edited and wild type allele. In two birds, we observed deletion of nucleotide 'G' at 179$^{th}$ position of the ORF while in other bird, we found substitution of nucleotide 'G' with 'T' at 179$^{th}$ position of the ORF. On account of deletion of nucleotide, the amino acids were substituted from the 60$^{th}$ codon onwards and premature termination of the translation was happened at 79$^{th}$ position of the protein sequence. In case of nucleotide substitution, amino acid (arginine) (60$^{th}$ codon of the gene) of the protein was replaced by arginine (R) with isoleucine (I) (R>I).

**Effect on growth:** Body weights at different ages were noted in edited and control birds where it was significantly ($P<0.05$) differed between these two groups of birds. Body weights in edited birds were 11 to 28% lower than those of control birds at different ages.

**Hormone profile:** Four reproductive hormones viz. FSH, LH, progesterone and estrogen were estimated in plasma of both the edited and control birds. The FSH level was 66.6% higher ($P<0.05$) in the edited birds as compared to the control birds. The LH level was 20.6% higher in the edited birds than the control ones. The progesterone level was 29.3% lower in the edited birds than that of control ones. The estrogen level was 98.1% higher in the edited birds than that of control birds.

**Egg production and quality traits:** Annual egg production in edited birds was 250 eggs while in control birds, it was 128eggs indicating 95.3% higher ($P<0.01$) egg production in edited group. Egg quality parameters were analysed in the edited and control birds at 31 weeks of age. The shell colour of eggs was brown in both the edited and control hens. Two parameters such as Haugh unit and yolk colour index differed significantly between the edited and control group of birds. The Haugh unit and yolk colour index was 19.8 and 17.5% higher, respectively in the edited birds as compared to the control hens. Other parameters such as albumin%, yolk%, shell%, albumin index, yolk index, shell thickness and egg shape index did not differ significantly between the edited and control group of birds. In addition, cholesterol and LDL content in eggs did not differ significantly between the edited and control birds.

It is concluded that the editing of exon1 of inhibin alpha gene had significant effect on enhancing egg production in native chicken.

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LP-03

# Shape of poultry sector in 2047 under Viksit Bharat

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By 2047, under the ambitious vision of *Viksit Bharat*, the Indian poultry industry is poised to evolve into a high-tech, nutrition-driven, and globally competitive sector. 'Viksit Bharat' means 'Developed India. Viksit Bharat 2047 is the Government of India's vision to transform the country into a completely developed nation by 2047, marking 100 years of independence. The economic goal would be to make it to 30 trillion USD economy with per capita income of 21,000 USD, It focuses on inclusive growth, innovation, sustainability, and good governance, ensuring prosperity for every section of society. The vision is based on four pillars: Youth, Poor, Women, and Farmers.

This write-up is an attempt to analyse the merits and limitations, advantages and disadvantages of Poultry sector in our country if it must rise in line with the vision of Viksit Bharat 2047. The strategic role of poultry sector in Viksit Bharat is broadly categorised into ensuring Nutrition and Protein security of 1.6 billion people by 2047, generating rural employment and focussing on Value addition and Agribusiness.

- Nutrition Security: Poultry will be central to India's goal of eradicating protein malnutrition, offering affordable, safe and healthy protein through eggs and meat which should be made available in every part of the country.
- Rural Employment: With agriculture's GDP share projected to decline to 12% from current share of 16%, allied sectors like poultry will absorb rural labour, especially benefiting youth, women, and small farmers.
- Value Addition and Agribusiness: Poultry farming will shift from raw production to — processing, packaging, branding, and exports.

  To take up the strategic role, and to execute the same in a foolproof and effective manner, Poultry sector must transform itself into a modern technologically driven agricultural activity like precision farming, biosecurity and veterinary infrastructure and sustainable practices.
- Precision Farming: Use of Internet of Things (IoT) that is, 'network of physical devices, vehicles, appliances and other objects embedded with sensors, software, connectivity, allowing them to collect and exchange data over the internet.' Artificial Intelligence (AI), and data analytics to monitor bird health, optimize feed, and predict outbreaks.
- Biosecurity and Veterinary Infrastructure: Enhanced veterinary services will ensure quick and definitive diagnosis of health issues, disease prevention and control, public health safety, and export readiness.
- Sustainable Practices: Focus on low-carbon operations, waste recycling, and water-efficient systems to align with India's net-zero goals.

A significant increase to country's GDP contribution through value chains (from current 1.5% to 3%),

stable employment generation in rural India especially for women, semi-skilled and skilled population and by exploiting export potential India has the potential to become a global poultry supplier. India aims to become the "food basket of the world." Poultry, with its short production cycles and high feed conversion efficiency, will be a key export commodity to regions in Africa, Southeast Asia, West Asian countries, Europe and the US. Currently, the poultry sector in India faces a mix of challenges that could hinder its growth if not addressed strategically.

1. Structural and operational challenges,
2. Environmental and regulatory pressures,
3. Food safety issues and market-related challenges

1. Structural and Operational Challenges are fragmented production, high feed cost and uncertainty in availability, various disease challenges, and limited cold chain infrastructure. Those key hurdles are explained below.

- Fragmented Production: A large portion of poultry production happens in unorganized manner, in the sense, in small sized farms with an average housing capacity of less than 10,000 broilers per cycle, which makes mechanisation and adopting technological advances unviable and scaling up production difficult leading to inconsistent quality, productivity and higher cost of production.
- High Feed Costs: Feed accounts for 60–70% of production costs. Price volatility and uncertainty in availability of major feed ingredients like maize and soybean cake, minor ingredients like major sources of calcium and phosphorous (DCP, Shell grit, marble chips), one hundred percent import dependent micro ingredients like vitamins and trace minerals, put together directly impacts profitability as well as create an environment of uncertainty.
- Disease Challenges: Viral diseases like Avian influenza, Newcastle Disease, Infectious Bronchitis, Infectious Laryngotracheitis, Infectious Bursal Disease, Inclusion body hepatitis, Marek's Disease and Bacterial diseases like Salmonellosis, Fowl Cholera, Coli bacillosis, Necrotic enteritis, Protozoan infection like Coccidiosis can cause massive losses, disrupt production process and trade. Further, can pose potential threat of zoonoses and food safety. Biosecurity remains a weak link in many small farms. Ever evolving virulence, pathogenicity, development of resistance to anti-microbial and anti-viral agents are considered as biggest threats to disease prevention and control.
- Limited Cold Chain Infrastructure: Inadequate storage and transportation facilities affect the shelf life and safety of poultry products, especially in remote areas.

2. Environmental and Regulatory Pressures include vulnerability to climate changes, waste management and pollution and regulatory hurdles which require a joint effort from farming community and statutory authorities.

- Climate Sensitivity: Poultry is highly vulnerable to both heat and cold stress, which affect growth rates, egg production, and mortality.
- Waste Management: Disposal of poultry litter and effluents is a growing concern, posing environmental hazard, pollution and social issues in especially near human dwellings and urban clusters.

- Regulatory Hurdles: Complex licensing, lack of uniform standards, and limited veterinary oversight slow down modernization efforts.

3. Food safety issues and market related challenges are in a way acting as nightmares for the poultry sector's stakeholders which include price fluctuations, export barriers, changing consumer preferences, food safety issues, contaminations etc.,

- Price Fluctuations: Seasonal demand and supply imbalances lead to unstable market prices, affecting both producers and consumers.
- Export Barriers: India's poultry exports are constrained by health certifications, food safety issues, trade restrictions, cutthroat price competition, incentives at country of origin and lack of global branding.
- Changing Consumer Preferences: Rising demand for antibiotic-free, organic and chemical toxin free, pesticide free and processed poultry requires a shift in production practices and higher investment.

To overcome those challenges poultry sector needs, investment in feed innovation, cold chains, and digital traceability, improvement in agriculture yield per acre in maize and soya production, quality raw material, feed raw material testing and feed analytical facilities, stronger veterinary services and disease surveillance, policy support for sustainable practices and export competitiveness, and putting equal focus on qualitative as well as quantitative growth. Poultry-Specific Challenges are Short Production Cycles, Consumer Sensitivity and Export Limitations

The poultry sector is more organised and vertically integrated than most other agriculture sectors, which gives it scalability—but also makes it more sensitive to input costs and health risks. In contrast, crop farming and dairy are more land and labour intensive, with slower cycles and deeper policy entanglements. These challenges have considerable Implications for food security goals of our country. The challenges facing the poultry sector have direct and far-reaching implications for India's food security—especially as the country aims to nourish 1.6 billion people by 2047 under the Viksit Bharat vision.

Over a period of last 3 decades or so, Broiler sector has undergone tremendous change in its structure. Until early 1990s broiler farming model was like day old chicks were supplied by Hatchery operator, compounded feed was procured from commercial feed manufacturer, and grown-up birds were sold to bird trader at farm gate. Entire risk of farming was borne by the farmer. Frequent outbreaks of diseases like ND and IBD in mid 1990s causing huge unbearable loss put broiler farming under severe stress. It led to emergence of new model of farming known as vertically integrated broiler farming. The entire risk is borne by Integrated operator.

However, current structure of Layer sector in India is entirely different from that of broiler. Issues faced by layer farmers during mid 1990s similar to broiler farmers, forced small farmers to close their farms. However, bigger layer farmers who could withstand the financial pressure continued their farming operations and expanded their farm capacity year on year. Currently layer farm size ranges from one lac to 20 lacs plus with majority farm size is 3 – 5 lacs. Several transformative interventions were seen in layer sector with adoption of newer technologies in housing, feed manufacturing, feeding,

automation in farm operation, enhanced biosecurity and food safety measures. That has opened export market for table eggs from India particularly from Namakkal and Erode districts of Tamil Nadu.

Government through its pro-industry and pro-agriculture policies has been supporting both sectors with several incentives and schemes like infrastructure funding, interest subvention on loans, credit guarantee schemes, massive subsidies for food processing units, feed mills etc., These supportive measures would go a long way in the massive expansion, value addition, quality improvement, employment generation and finally in making Indian poultry sector on par with that of developed counties. By 2047 annual broiler production is expected to increase from current number of 600 crore birds to 1900 crores and that of table eggs is expected to increase from 13000 crores to 35,000 crores. It could translate into per capita availability to cross 19.0 Kg broiler meat (from 6.7 kg in 2025) and 215 eggs (from 88 in 2025). Similarly compounded feed requirement will cross 125 MMT from current figure of 40 MMT (in 2025), Maize requirement will increase from 20 MMT to 60 MMT and Soy cake requirement will rise from 7 MMT to 22 MMT. Current estimated employment generation (direct and indirect) is around 50 lacs. It is estimated to double with the help of automation options available as adopted in other developed countries.

Current very low yield in maize and soya per acre causing higher price is sone of the constraints for the growth of Poultry sector. Massive improvement in agriculture practice and adopting high yielding variety of seeds might help along with importing of maize and soy cake as and when required. Similarly, to grow three times higher number of birds, poultry infrastructure development needs massive investment and congenial policy along with land availability. Disease challenges pose a major hurdles in productivity and food safety. Food safety issues and pollution norms will also play a crucial role in deciding the shape of Poultry sector. Hopefully poultry sector will overcome those limitations with the help of technology, advances in disease diagnostic and prevention methodologies, credit support from banking system, government support and private investment.

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LP-04

# Startup ecosystem in India-animal husbandry and poultry startups powering protein needs

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India on the mission of Vikasit Bharat by 2047 celebrating 100 years of independence. Both India and Bharat are positioned sufficiently with a powerful young India (more than 60 to 70 crore) powering the engine for growth consistently 7 – 8 per cent GDP growth annually. India is in fourth position just surpassing Japan recently in 2025 (India - 4.17 trillion dollars, Japan - 4.16 trillion dollars, June, 2025). Indian culture and heritage of 5000 years has made India a consumption economy (60 per cent), investment / savings economy (30 per cent) and 10 per cent as public spending. This strategy helps to navigate any internal or external turmoil of the economy. It is predicted by Morgan Stanley that India will be 3rd largest economy surpassing Germany by 2028 with 5.7 trillion Economy.

As per the recent economic survey 2025, 56 per cent of the GDP of India is from services, 20 percent is from manufacturing / industry and Agriculture Sector which holds Animal Husbandry contributes 15 to 16 per cent of India's GDP. Animal Husbandry in particular contributes 31 per cent of the Agriculture Sector and which translates into 5 per cent of National GDP.

In this chapter, it's an attempt to present changing demographic atmosphere in India, energetic, optimistic young India, transformation of Agriculture and Animal Husbandry sectors not only as livelihood sectors but also as business opportunities. The culture of Entrepreneurship is not new to India. In any village setup from age-old times self-sustainable agriculture, running the family was a culture and Atmanirbhar Family / Village was very common earlier.

After independence, the employment from public sector organizations especially defense, Railways, Navratnas, police, banks etc., were seen as the only opportunity for employment. The new generation has totally changed that perspective may be because of dearth of opportunities in getting government jobs and abundant opportunities in private sector for employment. This strategy was well adopted as campus placements for engineering graduates of software and allied sectors. The increased purchasing power and the aspirational India with the youth has again taken a paradigm shift since two decades. Especially after 2015 to 2025.

The present buzz word in any millennials or Genz is "Startup". The word startup itself embodies *to begin, to rise or to standup himself / herself*. The ecosystem in the economy which is growing at 7 to 8 per cent and abundant availability of capital / venture capital etc., are fueling the dreams of young India to start their own enterprises.

This startup wave or culture started first in Silicon Valley (US) shifted its epicenter to Shanghai (China) and now found a new epicenter in the globe Bengaluru (India). Many Indian young leaders have become the global leaders of the world for global companies. To name a few Satya Nadella of Microsoft, Sundar Pichai of Alphabet, Lakshman Narayanan of Starbucks, Arvinda Krishna of IBM

and Shantanu Narayan of Adobe to name a few among 25 global CEOs of Indian Origin. Further, Indians have proved their mettle and grit in establishing startups / unicorns (valued at 1 billion USD) in Silicon Valley. As per the latest updates, among the top 20 countries of Indian origin of immigrant founders of US Unicorns, India stands No. 1 with 66 Unicorns in US followed by Israel at 54.

**Indian Animal Husbandry Sector an Overview:**

Indian Animal Husbandry Sector contributes 5% to the GDP of India (200 billion USD / 17 to 18 lakh crore rupees). It has a share of 31% of agriculture contribution to GDP (about 600 billion USD / 50 to 60 lakh crore). Animal Husbandry sector in India is growing consistently at an average of CAGR of 6 – 7% yoy. It provides direct and indirect employment to about more than 100 to 120 million people (full population of few countries). In India the livestock sector is a '*livelihood sector'* providing life and food to millions of population. A recent Mackenzie report predicted a phenomenal growth for Indian livestock sector to achieve 1 trillion USD contribution by 2047 (Vikasit Bharat) increasing its share to 50% of agriculture sector.

Indian Dairy is No.1 in the world producing 240MMTs of Milk per year (2024-25). 60% of the sector is unorganized (livelihood sector), 40% is organized. 55% if organized sector is cooperative sector. Amul the taste of India is a leading example for the global leadership with a turnover of about 1 lakh crore as a corporate giant. Daily in India 10 to 15 crore (100 to 150 million) liters of milk is processed in organized sector. The different models of dairy include two cow model (sustainable livelihood model), 10 to 15 cow model (cooperative business entity), 20 to 25 cow model (aggregator cum startup model for a branded product), 100 to 500 cow model (branded end to end dairy company). The biggest dairy farm in India is Bhagyalakshmi Dairy Farm (3,500 cows) of Parag Dairy Group in Maharashtra.

Indian Poultry Sector contributes about 30 billion USD / 2.8 to 3.0 lakh crore rupees to livestock sector. Daily 250 to 300 million eggs are produced in India and about 15 million broilers are placed daily in India. About 5.5 crore broiler breeders are placed annually in India. The other sunrise sectors are Sheep & Goat farming as an entrepreneurship because of push of Government of India schemes like National Livestock Mission (NLM) by giving up to 50 lakhs subsidy creating business models across the country. The piggery farming is also considered as a great venture with investments up to 5 to 10 crores around metros for supply of quality branded pork surrounding consumption areas.

Indian livestock sector is driven now by technology, high genetic livestock, best in class management practices matching productivity of global standards to the world. Poultry sector is almost 90% organized with best broiler, layer and breeder units across the country. The large broiler units being up to half a million broilers at one place and 3 million layers at one place matching the scale and efficiency at global level. The Govt. of India schemes like Animal Husbandry Infrastructure Development Fund (AHIDF) has given a great push for modern infrastructure, technology adoption and innovation with 3 per cent interest subvention and allocation of highest budget 15,000 crores (2024-25) and up to 30,000 crores (2025-26).

**Heart of Animal Husbandry Sector – Feed and Feed Ingredients for livestock:**

Animal Husbandry sector depends directly on agriculture sector of India as feed/feed ingredients forms 70% of the cost of production. Corn and Soya dominate in livestock feed with corn occupying

50 – 60%, Soya 20 – 30% in livestock diet. Indian monsoon determines the output of both important ingredients yoy. During 2024-25 the demand for ethanol from corn has constrained the supply of corn to livestock sector. The general demand of corn for livestock sector is around 20 - 25 MMTs every year (2024-25) of which 15-20 MMTs is required by poultry, 4-5 MMTs cattle and rest for human requirement and seed. Generally, corn takes care the energy component of the feed. States like Bihar, Madhya Pradesh, Maharashtra, Karnataka contributes 80% of corn production in India.

Finally, Indian livestock sector being livelihood sector has to have a strategy of *"volume by large players and value by small players"* as a Mantra for meeting the demand of 1.5 billion Indians for Milk, Meat, Eggs.

**Overview of Indian Startup Ecosystems:**

Startup ecosystem in India has taken a quantum jump from single digit number two decades back to more than 1,50,000 registered aspirational startups in various categories of sectors in India. There are 118 registered unicorn startups in India with more than 25 Unicorns in services, 20 unicorns in Fintech, 15 unicorns in SAAS (Software as A Service), 20 Unicorns in E-commerce, 15 to 18 Unicorns in Marketplace etc. Interesting to note that 15 Unicorns are having Women as founders of startup.

**Innovation in Agri and Animal Husbandry Sector:**

The educated youth approaching as co-founders or in a group to solve a problem which is affecting common people either in Agri or in Animal Husbandry has evolved into a business opportunity or a startup. The commonalities in the founders are conviction, commitment and confidence to scale up the solutions at reasonable cost and reach to larger population. The mantra for startups is innovation, disruption, techno-commercial perspective, adoption of technologies like data for decision, AI, ML, IoT. The culture in the colleges across India for the youth is academic to aspiration, confusion to confidence, no capital to abundant capital availability etc., are the sunshine in the horizon.

**Inspirational Agri-startups:**

India being an agrarian country, has reached a stage of country to export food ingredients from a begging bowl after independence. The record production of Rice - 150 MMTs, Wheat – 110MMTs, Vegetables and fruits – 340 MMTs etc., testifies the achievements of Indian farmer at Pinnacle. However, it's a challenge when it comes to better price realization for farmers and to balance demand and supply of produce at right quantity and right price for both farmers and consumers. The other major challenge Agriculture is facing is supply chain stability i.e., cold chain, storage etc., for avoiding wastages.

Many founders of startups across the country saw this as a opportunity to solve such major problems at scale. To mention few of them "Way cool" India's leading food an Agritech company with a tagline "Re-imagining the food supply chain by flipping the ecosystem from supply-led to demand driven". They claim that they have reduced the supply chain wastage of agriculture produce like vegetables, fruits, staples etc., from 20 to 30 per cent to 1 percent. They are operating across 2,900 locations across India and UAE, more than 100 procurement locations, 133 processing units, 412 distribution points with more than 2 lakh customer networks.

Similar are the stories of "Ninja Cart" who are exemplified for creating direct network of farmers to consumers via business-to-business models (B2B). They are approaching the status of Unicorn soon.

They are operating from Bengaluru supplying to Bigbasket etc., as B2B business. The other startup is “Dehaat”, “Reshamandi”, “Vegro”, “Absolute”, “Agrostar” etc., are a few leaders in Agri startups.

**Case Study of DeHaat Startup:**

The founders identified following pain points before starting this startup:

I. **Farmers End:**

1. High cost of agri inputs 2. Multiple channels and layers for various services, 3. Poor yield of crops and income, 4. Relying upon local vendors.

II. **Agri-business:**

1. 40 per cent post-harvest loss for bulk buyers.
2. 35 per cent input market belongs to local brands.
3. Less than 10-12 percent farmers have access to credit and insurance.
4. Business leaders have no access directly to farmers.

**One-stop solution for farmers:**

The startup “DeHaat” introduced three-pronged approach covering Agri-inputs, crop advisory / credit / insurance and market linkage of produce. By solving the above pain points, they have obtained results for farmers like 10 to 15 percent saving in direct cost related to seeds, fertilizers, pesticides and other inputs directly from the startup. Direct crop advisory and credit and insurance linkages have given 20 percent increment in farm productivity. By managing market linkage of the produce, they claim up to 15 percent better price discovery.

**Status of DeHaat:** 4 lakh farmers, 7 lakh area under management, 1,500 DeHaat micro entrepreneurs, 600MTs of produce marketed per day, 7000 Agri input orders per day, 7 lakhs minutes per month spent on crop advisory with a revenue run rate of 80 to 90 crore monthly.

**Animal Husbandry Sector as a Business:**

Animal Husbandry contributing about 20 lakh crore with Dairy at 12 lakh crore, poultry at 3 lakh crore and sheep & goat at 2-3 lakh crore. Majority of the sector is at grassroots especially Dairy is driven by major stakeholder cooperative sector namely Amul, Nandini etc. Dairy as a corporate business is making inroads in few of the states where cooperative network is not well established. Nestle, Hatsun, Parag Dairy, Tirumala etc., are functioning as a corporate business entities.

Poultry sector is pretty much organized with dominant players like Venky’s, Suguna, IB group etc., running corporate structures with integration / contract farming as a dominant model. Sheep & Goat, Piggery etc., have not taken a shape of large business entities. These activities are driven by individual entrepreneurs.

**Startup ecosystem in Dairy:**

India being a dairy of the world with No. 1 position producing 240 MMTs per year and achieving 471 grams of milk as per capita availability which is much above the global average of 350 grams. Consumer in metros having more purchasing power and expecting convenience and superior quality has given an opportunity for evolving startups in dairy sector.

**Case Study:**

**Problem statement** – need of high quality certified milk at doorstep with traceability, transparency for consumers.

**Startups** – Akshyakalpa, Sid Farms, Milky Mist etc., have attempted to solve the above problem and achieved revenue run rates of in excess of 300 to 500 crores per year.

**Business Model** – The startups identify pain points at each stage of supply chain "from cow to consumer". They identify farmers family at village level and encourage them to completely involve as a model farmer family and start with 15 to 25 dairy animals (cows and buffaloes). They standardize the whole supply chain as a standard operating procedure with help of digital technologies like IoT etc., so that the quality of milk is standardized across the value chain. The other interesting observation is introduction of TMR, Silage, monitoring weather parameters like humidity, temperature etc., have augmented their productivity. Farmer partners are assured of online digital payments at promised time so that cashflow management / working capital management is efficient.

These startups are focusing premium segment of customers at any metros where the demand of such milk is about 1 - 3 lakh liters per day in that city. Introduction of efficient cold chain processors and packaging and branding with lot of marketing have made consumer to choose among the choices of startups. These startups are being funded by venture capitals across the globe up to the tune of 10 – 20 million USDs for their requirement to scaleup and spread across India.

CEAH Academy has documented Dairy startups in detail in its podcast series in Youtube Channel: CEAH Bengaluru Academy with this link:

https://www.youtube.com/playlist?list=PLZAVjFKbRpXtEz4-FvScw3DenO4QCVYq4

**Startup ecosystem in Poultry:**

Poultry farming has transformed from a backyard farming to a highly organized techno-commercial sector driven by efficient management system, precise nutrition, optimum genetics, efficient biosecurity, effective vaccinations and precise data monitoring has made Indian Poultry matching global standards.

Venkateswara Hatcheries Group (VH Group), Suguna, Indian Broiler (IB Group), Skylark, Shalimar, Sneha etc., are the trend setters for establishing corporate structures and efficient management of demand and supply of poultry products namely, hatching eggs, day old chicks, table eggs, meat etc. Recent phenomenon of managing processed product efficiently have thrown up an opportunity for startups in entering branded product segment to change chicken and egg from commodity to brand.

**Problem statement** – consumer demand for traceable quality meat and eggs at doorstep through omni-channel marketing.

**Startups in poultry** – Licious, Fresh to Home, Eggoz, Tenderfresh, Sneha etc are the trend setters in Metros transforming the buying experience of consumer. The presentation packaging has revolutionized from a black polythene bag for meat and paper wrap for eggs to the presentation of gift box kind of packing at doorstep of the consumer within 10 minutes on order by help of quick commerce and other omni channel distribution at convenience.

**Business Model** – Generally they run an asset light business (no big investment on production infrastructure). However, they create unique standards for quality of the meat and eggs both in production and final product. These interventions will ultimately yield final quality product to reach consumer with various parameters being tested and transparently communicated to the consumer as a price paid meeting value for money. They are operating in and around metros and tier-2, tier-3 cities to capture up to 1 – 3 percent of the retail market.

CEAH Academy has documented Poultry startups in detail in its podcast series in Youtube Channel: CEAH Bengaluru Academy with this link:

https://www.youtube.com/playlist?list=PLZAVjFKbRpXtEz4-FvScw3DenO4QCVYq4

Several attempts have been made to have a small startup ecosystem around sheep meat, goat milk and pork at different pockets across the country. The schemes of Government of India namely National Livestock Mission (NLM), Animal Husbandry Infrastructure Development Fund (AHIDF), Livestock Health Disease Control Programme (LHDCP), Rashtriya Gokul Mission (RGM), National Programme on Dairy Development (NPDD) etc., have created a pragmatic ecosystem for many players to enter the arena.

**Conclusions**

India, poised to become the third largest economy with young youth force powering the consistent GDP growth would definitely put more money in the hands of common citizen or consumer. Food being the priority for any household, his / her choice on healthy, safe and protein rich food becomes a choice for their expenditure in food basket. Animal Husbandry offers a right choice with milk, meat and eggs with full of essential vitamins, minerals and protein required to meet the dietary requirements for all.

India leading the digital highway for the globe with great platforms like Aadhar (for individual identity), Unified Payment Interface (UPI) – payment gateway for ease of business, 5G network for faster connectivity and democratization of market platforms through initiatives like Open Network for Digital Commerce (ONDC) etc., are the new highways of network for any individual to think as a enabling platforms for starting startups.

Sustainable startups require consistency, perseverance, profitability and equitable distribution of profits so that these startups can become a generational global companies like Tata, Reliance, Godrej, Mahindra etc., as global companies of India.

LP-05

# Phytase: Insights and Learnings

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Phytase has emerged as a pivotal enzyme in contemporary poultry nutrition due to its ability to hydrolyse phytate, thereby liberating bound phosphorus and other essential nutrients. This enzymatic activity enhances nutrient bioavailability, optimizes growth performance, and reduces dependence on inorganic phosphorus supplementation. As a result, phytase contributes to substantial reductions in feed costs and mitigates environmental phosphorus excretion, positioning it as the most impactful feed enzyme in terms of both economic efficiency and sustainability within poultry production systems.

Over the past several decades, extensive research has elucidated the biochemical mechanisms underlying phytase activity, providing a comprehensive understanding of the multifaceted benefits associated with phytate hydrolysis. These findings have been instrumental in the rational design and optimization of next-generation phytase variants, which exhibit improved catalytic efficacy under gastrointestinal conditions and greater resilience to dietary and physiological factors.

The objective of this lecture is to synthesize fundamental knowledge on phytase, with particular emphasis on its nutritional role, the determinants of its activity, and methodological approaches for critically evaluating its contribution to poultry diets. Such evaluation is essential for tailoring enzyme-based nutritional strategies to diverse production objectives and market contexts. In addition, recent advances in phytase research have generated novel insights into the performance of new-generation phytase products, further enriching the scientific narrative surrounding this enzyme.

Beyond its established role in improving nutrient digestibility and availability, emerging evidence highlights indirect effects of phytase on metabolic regulation and systemic physiology. These findings broaden the scope of phytase application, underscoring its role not merely as a phosphorus-releasing enzyme but as a multifunctional nutritional tool. Collectively, phytase enhances nutrient utilization, reduces dietary costs, improves bird performance, and supports the long-term sustainability of poultry production.

LP-06

# Precision feeding in layers: A game changer in egg production

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Poultry industry in India is in a dynamic state, the commercial layer industry is second in the world with nearly 36 crore birds producing 114.92 billion eggs annually (DHAD, 2024). The annual growth of the commercial layer industry ranges between 3 to 4%. The average feed consumption/bird/day is 0.11kg. based on this the annual feed requirement is around 15million tons, the grain requirement is 8 to 9MMT, Oil meal requirement is around 3MMT. The feed per egg ranges from 114gm to 140 gm in various situations in commercial layer farms, the average will be 127gm/egg, by optimizing the nutrient (precision feeding) in the feed in tune with the requirements of the bird and plan to reduce the feed/egg by 5gms (122gms/egg) the feed requirement for the layers can be reduced by 5.8lakh metric tons/annum, this will save approximately 14.5 billion rupees/annum, further the grain requirement is reduced to the extent of 3.5lakh tons/annum leading to reduction of 1lakh hectare of land in terms of maize area and 1.4 lakh hectares can be spared by reducing the oil meal requirement in terms of soybean meal.

**Precision Feeding:**

Precision feeding is the practice of meeting the nutrient requirement of animals as accurately as possible in the interest of a safe, high quality and efficient production while ensuring the lowest possible load on the environment (Banhaziet al., 2012)

**Critical factors for precision feeding:**

1. Nutrient requirements for various stages of production
2. Raw material quality
3. Formulation
4. Feed manufacturing
5. Disease challenges

**Nutrient requirements for various stages of production:**

The genetic selection for efficiency we find the body weight of the layer decreasing over the period and increase in the production potential of the birds, in the 1980s the HH egg production was 240 eggs, in the 1990s it became 300eggs, in the 2000s 330eggs now in 100 weeks it is ranging from 472 to 490 eggs in different strains, hence we are dependent on the breeder company for giving us the nutrient requirement.

In a large country like India with highly variable climatic conditions the nutrient requirement recommendations of the breeder companies can be assumed as a guideline only. Institutes should work on developing matrix for arriving at the nutrient need of the birds suitable for the local conditions. For example, assuming the maximum and minimum temperature for arriving at the ME requirement without considering the relative humidity will not work as 40$^{o}$ C at 50% humidity with nil air movement the effective temperature will be 40$^{o}$ C whereas at 70% RH it will be 43$^{o}$ C.

In the current layer, calcium can be assumed as the first critical nutrient, as in the field conditions the layer is observed to eat 10 to 15 gms more feed to meet the calcium need. Managing the calcium need of the bird efficiently helps in extending the laying cycle up to 100 weeks without moulting.

**Raw material:**

The greatest challenge we have is not only quality of raw materials but availability of raw materials. The protein content of oil meals varies very much; the variation range minimum is 10%. The major grain source is maize the ME content we assume as 3300kcal/kg and formulate. The ME content of various samples of maize evaluated in NIR ranged between 3150 to 3302 kcal/kg, when assumed as 3300 kcal/kg the bird adjusts by increasing the feed consumption up to 10gms/day. During physical evaluation grain count in 100gms of maize was between 350 to 390. The ME variation linearly correlates with the density. We conducted a pilot study by taking one litre weight of maize (test weight) and there was a positive correlation with the ME, when the test weight was 750gms the ME value was 3250 for every 10gms increase or decrease over 750gms in the test weight increase or decrease 25kcal. This was done with a smaller number of samples, institutes should work with a greater number of samples and trials to be conducted for different raw materials, calibrate the NIR and correlate this with the test weight of the raw materials, as every farmer who manufacture his own feed cannot afford NIR. Protein can be estimated, but for amino acid published data is used, data for digestible amino acids are also available. The protein content is estimated and based on it the amino acid content is calculated on pro rata basis but it is not always correct, the percentage of critical amino acids in the soybean protein decreases as the protein content increases, indicating increased percentage of non-essential amino acids (Medic et al 2014). Antinutritional factors and toxins should be known to maintain them below the tolerance level.

**Formulation:**

Good software's are available for efficient and speedy formulation. Nutritionists can develop their own software in MS Excel and formulate using the solver option in the Excel, this will help to upgrade their software to incorporate new parameters without depending on the software provider. Formulation is not only based on the nutrient requirement but also should contain additives like probiotics and acidifier to enhance the gut health, immunity, enzymes to enhance the digestibility

**Feed manufacturing:**

Pellet, crumble and Mash feed are used in feeding layers. In my opinion mash feed is better as the larger particle size helps the gizzard development, a well-developed gizzard is considered as an efficient grinder as the grinding is done with the feed mixed with endogenous enzymes and bile.

**Disease challenges:**

Layer industry in India is in clusters concentrated in certain districts in various states, sometimes the maximum distance between two farms is only the fence, the vaccination schedule differs according to the area and concentration of the birds, further, publications are there indicating the safe titre levels of antibodies against an endemic disease varies according to the population of the birds and endemicity of the disease.

The protein/amino acid requirement for immunity is higher than that required for egg production. Birds fed with feed containing 16% protein and 18% protein had nearly the same egg production (94.5%

vs 95% respectively) but the antibody titer against Newcastle disease was 2.5 vs 4.17 respectively (Bunchasak et al 2005)**.** As the genetic selection for improved performance is a continuous process, the current strains response to challenges is more of inflammatory rather than adaptive immunity (Cheema et al, 2003), resulting in decreased productivity. The nutrient requirement research should also include area specific immunomodulatory need, or else the farmer may lose at least 20 eggs for each outbreak of the endemic disease.

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# Pathogen evolution changing the dynamics of poultry industry

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## 1. How industrialized farming practices might shape the evolution of 'virulence':

Pathogen evolution can have devastating impacts on livelihoods and sustainability. Higher virulence is positively associated with increasing rates of transmission, a trade-off between transmission and mortality. Both the higher turnover rate and higher environmental persistence in markets relative to farms could select for higher optimal virulence strategies. These high rates of mortality, alongside the high frequency of disease outbreaks, make all these viruses major barriers to the sustainability of poultry as both food and economic resources in both industrialized and less-industrialized communities. Live bird markets are known to shape prevalence and persistence of poultry pathogens indicating that they may also affect poultry pathogen evolution.

Several husbandry practices that either increase the transmission benefits of virulence, or reduce the mortality costs of virulence ultimately selecting for increased virulence. They include vaccination with 'imperfect' vaccines, dramatic decreases in host lifespan in modern broiler poultry populations to fifty days or less, and cleaning between cohorts of poultry that does not completely eliminate the pathogen. The occurrence of unanticipated new diseases and new legislation in several countries will also remain essential issues. One such approach was introduction of "no antibiotic ever" approach in poultry production in some countries has led to a shift in the disease profile primarily characterised by an increased prevalence and severity of enteric diseases such as coccidiosis and necrotic enteritis.

## 2. Evolution of the virulence strategy of poultry pathogen in India:

**The development of the modern poultry industry,** has facilitated the spread of many poultry diseases**.** Marek's disease virus (MDV), Newcastle disease virus (NDV), and avian influenza virus (AIV), H5N1 are the three deadliest pathogens that circulate in poultry populations. Since their discovery, all three pathogens have been shown to circulate worldwide, and the most virulent strains of each have been reported to kill up to 100% of poultry flocks.

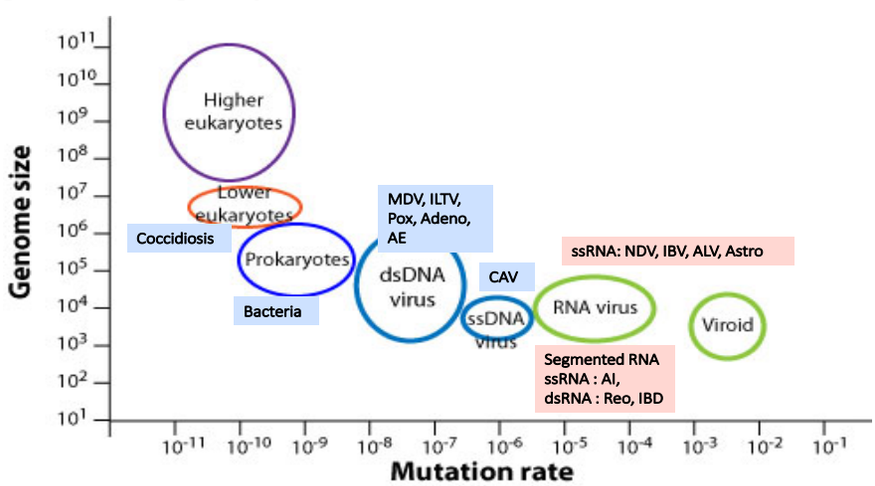



**Fig. 1: Mutation rates per nucleotide versus genome size for different organisms.**

RNA viruses of poultry (NDV, IBV, AIV, Astrovirus, Reovirus, and IBD) are characterised by extremely high genetic variability due to fast replication, large population size, low fidelity, and (usually) a lack of proofreading mechanisms of RNA polymerases leading to high mutation rates (Poultry pathogen mutation rate highlighted in Fig.1). Furthermore, viral recombination and reassortment may act as a significant evolutionary force among viruses contributing to greater genetic diversity than obtainable by mutation alone. The above-mentioned properties allow for the rapid evolution of RNA viruses, which may result in difficulties in viral eradication, changes in virulence and pathogenicity, and lead to events such as cross-species transmissions.

While vertically transmitted diseases are a **significant and persistent challenge**, are the major threats in the future, **which includes Mycoplasma, Salmonella, Avian encephalomyelitis, Chicken astrovirus, Avian Reoviruses, Fowl adenovirus etc. Some of these diseases would be discussed briefly, quoting the reasons for its evolution in poultry.**

### 3. Oncogenic Marek's disease

Marek's disease virus (MDV) is a cancer-causing herpes virus became economically important with the intensification of the poultry industry. The disease is difficult to eradicate as the virus is able to survive for long periods both in the host and in the environment of the poultry house. Successful vaccination therefore, remains the only strategy to control the disease. Vaccination of chickens with live HVT virus from a related non-oncogenic strain was used from the late 1960s. This first generation vaccine initially provided good control, but within a decade it was not providing adequate protection against virulent viral strains that appeared in the 1970s. In the 1980s, a second generation vaccine consisting of two non-oncogenic HVT + SB1 strains was introduced, but this too began to fail as more virulent strains subsequently evolved. In the 1990s a third generation vaccine consisting of an attenuated form of an oncogenic Rispen's strain was introduced. Losses have once again subsided, but there is great concern in the poultry industry that the third generation vaccine may eventually be undermined by the evolution of even more pathogenic strains (Details in Fig.2). Importantly, the two generations of vaccine that failed were undermined by strains antigenically identical to the oncogenic strains of the pre-vaccine era. Changes in viral aggression and immunosuppressive capacity, not antigenic type, caused the vaccine failure.

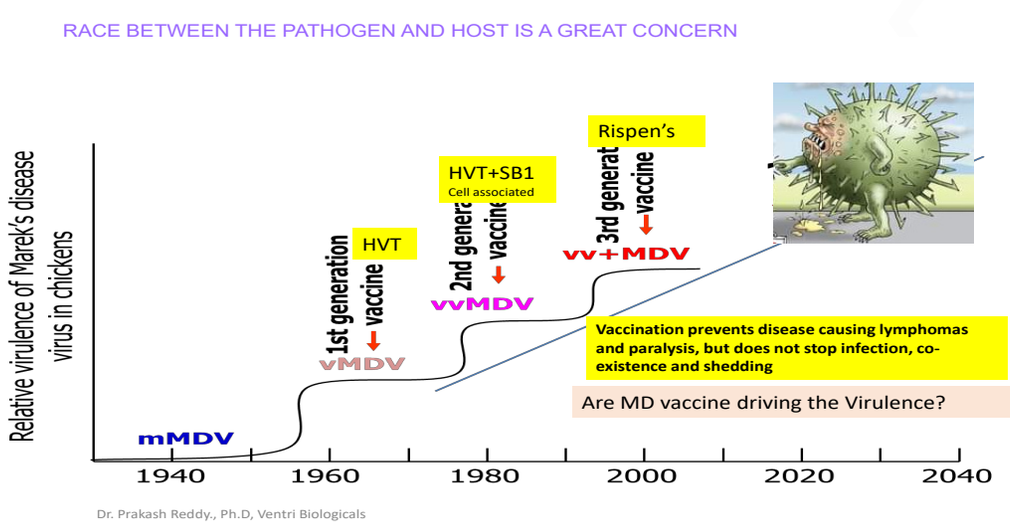



**Fig 2: Increasing virulence of Marek's and the introduction of different vaccine strains**

**4. Continuously re-emerging Newcastle disease:**

Newcastle Disease is the second most widespread disease globally, affecting many countries after rabies with significant prevalence. High number of outbreaks have been recorded in Asia followed by African region with least impact in Europe and United States. Given its worldwide prevalence in well-entrenched epidemic form, this disease poses a permanent threat to 131 countries, since 2005 in poultry. Iran is the country with highest burden of NDV outbreaks followed by Vietnam, China, India and Afghanistan.

Ever since the first emergence in 1926, there have been five global ND pandemics, each originated by distinct genotypes as indicated in the Fig.3. The first pandemic, spanning from 1920 to 1960, emerged concurrently in Southeast Asia and Europe, requiring approximately three decades to proliferate globally. This pandemic was driven by NDV variants possessing genotypes I, II, III, and IV. Several lentogenic and mesogenic live vaccine strains were developed during this period. Presently, the fourth ongoing pandemic, believed to have commenced in the late 1980s, is linked to genotypes V, VI, VIII and more specifically VII.1. Genotype VII has played a significant role in the most recent fourth pandemic, becoming the dominant strain globally, with sub-genotype VIIa primarily impacting countries in Asia and Europe, whereas genotype VIIb (XIII) is more prevalent in India and South Africa. Furthermore, sub-genotypes VIIc, d, e, f, g, and h have been identified in isolates from China, Kazakhstan, aznd South Africa. Currently, fifth panzootic was originated in Asia in late 2000 with genotype VII.2 (VIIi) prominently. The newly characterized sub-genotype VIIi is deemed enzootic due to widespread outbreaks in Indonesia since 2010, Pakistan and Israel since 2013 and in India since 2023. Based on the updated unified phylogenetic classification system for NDV, sub-genotypes VII.2 and XIII.1.2 were formerly named VIIi and VIIb, respectively.

Three genotypes (IV, VII and XIII) belonging to 5 different classes have been recorded in India till date. Genotype XIIIb was first reported in 2006 in commercial chickens; while the ancestral strain Genotype VII existence is dated back to 1982 in Cockatoo and 1989 in chickens at Tamil nadu. Recently, NDV isolated from commercial ND vaccinated farms of Chhattisgarh region revealed the presence of genotype VII.2 (VIIi) caused outbreaks in 2023, is spreading across the country. In addition, emergence of novel genotypes XXII.1 and XXII.2 from North-Eastern states are being witnessed in the country. Furthermore, the recent strains showed a strong nucleotide similarity, suggesting a common ancestor closely related to Genotype VII indicating the potential influence of geographic and environmental factors on strain evolution and distribution. Comparatively higher death rates in chickens and other poultry were observed to be associated with Genotype XIII than Genotype VII. Early vaccine strains were based on older genotypes (II, III & IV) and could not effectively protect against newly emerging, genetically diverse field strains, so the vaccine development shifted to include genetically matched strains to improve protection, particularly against recent virulent strains.

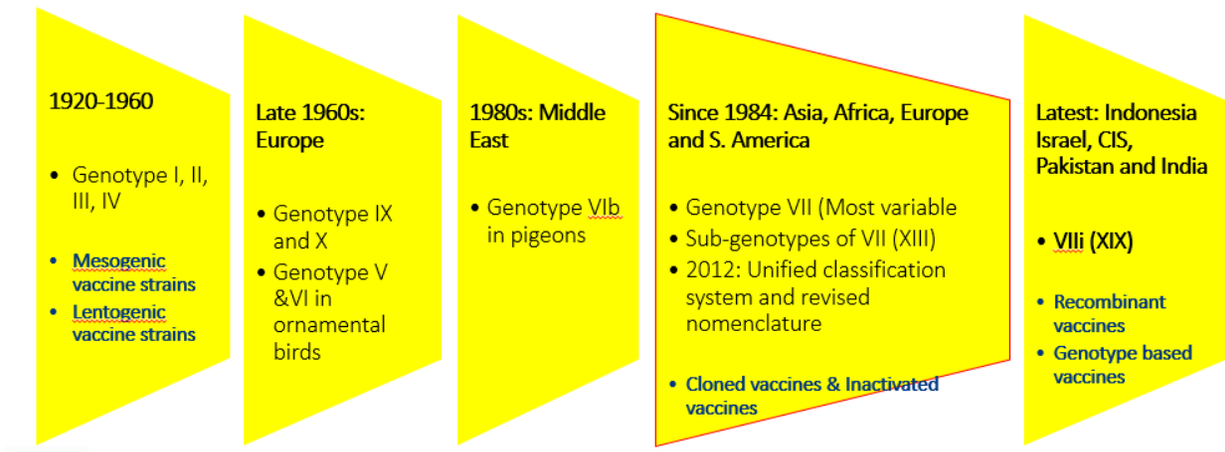



**Fig. 3: NDV Pandemics and evolution of NDV genotypes**

## 5. Avian influenza: The Global threat

The avian influenza virus strains have been circulating and diversifying in wild bird populations for at least the last 100 years. Wild migratory birds can transport AIV along their migration routes, and contact between wild and domestic avian populations sometimes results in transmission between the two. Being a segmented RNA virus influenza viruses has a potential to undergo genetic alteration by viral antigenic shift by segment reassortment and drift by recombination/mutation is of concern, leading to a new strain that may be more virulent or escape existing immunity.

Valuable lessons have been learned from past avian influenza epidemics in various countries globally, but there are still knowledge gaps. One important lesson learned is that the avian influenza virus is zoonotic, meaning it can be transmitted from birds to humans. Infection with avian influenza viruses, such as the H5N1 and H7N9 strains, is particularly notable for causing severe disease in humans. However, person–to–person transmission is uncommon, but when it occurs it can result in severe disease and death. So, for the purposes of the *Terrestrial Code*, both H5/H7 HPAI and LPAI in poultry are termed “avian influenza” and are notifiable. Low pathogenic non-H5 and non-H7 influenza A viruses (i.e. H1–4, H6 and H8–18) are not defined as avian influenza and are not notifiable.

Looking to the future, we should expect the emergence of more HPAI strains. It’s quite possible that HPAI H5 will continue to circulate and diversify, especially for clade 2.3.4.4, because it does not necessarily cause severe clinical signs in its wild hosts and is therefore capable of silent spread. Hence increasing biosecurity and vaccination in domestic poultry are likely to be important strategies to keep outbreaks in these populations to a minimum. The success of the H7N9 vaccination programme in China suggests that it is possible to control virus circulation in domestic birds and thus vastly reduce the number of human infections and the risk of ongoing human to human spread. Therefore, if we continue the disease surveillance programmes in avian, human and other domestic animal populations, and control avian influenza in domestic avian populations, then we can surely reduce the risks of a new human avian influenza pandemic.

Low pathogenic H9N2 influenza virus established stable poultry adapted lineages whose prevalence have increased exponentially, affecting many countries worldwide. Limited surveillance, subclinical circulation in poultry, less than optimal vaccination approaches, and the non-reportable status of H9

have contributed to their perpetuation in poultry and the emergence of zoonotic strains of pandemic concern. H9N2 have been isolated from numerous sylvatic and domestic animals, such as wild birds, pigs, horses, dogs, cats, pikas, and minks, which highlight their potential for expanded host range.

The economic impact of H9N2 infection in poultry have led many countries to adopt vaccination programs as means for prevention and control. China implemented a long-term vaccination program in chicken farms as early as 1998, followed by Italy, Israel, South Korea, Morocco, Pakistan, Egypt, Iran, and the United Arab Emirates have adopted similar vaccination efforts. Recently in India, The National Institute of High Security Animal Diseases (ICAR-NIHSAD) in Bhopal, developed the first indigenous vaccine for the H9N2 G1-W lineage virus in chickens. The technology was transferred to four poultry vaccine manufacturing companies in India and the licensed vaccines are available in the Indian market.

Vaccination, typically in the form of an inactivated virus, has been proven effective in mitigating clinical disease and production losses, but has failed to control H9N2 virus spread due antigenic drift driven by poor vaccine antigenic match. So, matching the seed vaccine strain with the viruses circulating in the field is the key to successful immunization efforts.

**6. Ubiquitous Avian Reovirus (ARV):**

ARV has a very high global prevalence, with most studies indicating that it is present in nearly all poultry flocks worldwide, meaning the prevalence rate is essentially considered "ubiquitous" or close to 100% in commercial poultry populations. Studies often report positive detection rates in the vast majority of flocks sampled, with some studies showing positive results in over 90% of flocks.

ARV is now a moving target, similar to the influenza virus, due to its genetic nature. The incidence of ARVs in the intestines of wild birds was greater than that of ARVs in their excrement. Overall, several genotypes circulate among the poultry population, and no significant cross-protection has been reported among different genotypes. At least six distinct genotypes were found when ARVs were genotyped utilizing the σC-encoding gene; however, the relationships between genotypes, pathogenic traits, and serotype classifications are still being determined. ARVs exhibit a broad range of tissue tropisms, which include respiratory signs, enteritis, runting–stunting syndrome, malabsorption, tenosynovitis/arthritis, hydropericardium, hepatitis and unidentified cases. The nonspecific geographic distribution of all six ARV genotyping cluster groups indicated that vaccine formulations containing appropriate antigens from all six genotypes are necessary for the successful prevention of viral-induced arthritis/tenosynovitis.

Despite decades of routine vaccination with traditional strains (S1133, 1733 and 2408) implemented since the 1970's in other countries, the emergence of vaccine resistant ARV isolates is suspected as a primary factor driving the outbreaks. The inherent reassortment, high mutation rate, and recombination potential combined with the development of immune escape variants under selective pressure from these vaccines has contributed to the decline of vaccine efficacy. Consequently, a comprehensive characterisation of circulating ARV strains is crucial for developing effective control strategies. Furthermore, the increased use of autogenous vaccines has been associated with positive selection, leading to a diverse range of virulent strains.

The lack of surveillance for ARV in India is more of an ongoing challenge which is hard-to-track variants. To combat this, continuous, large-scale epidemiological surveillance and genetic characterization are needed to keep up with emerging ARV variants, inform vaccine reformulations, and develop better prevention strategies against the significant economic threat to the poultry industry.

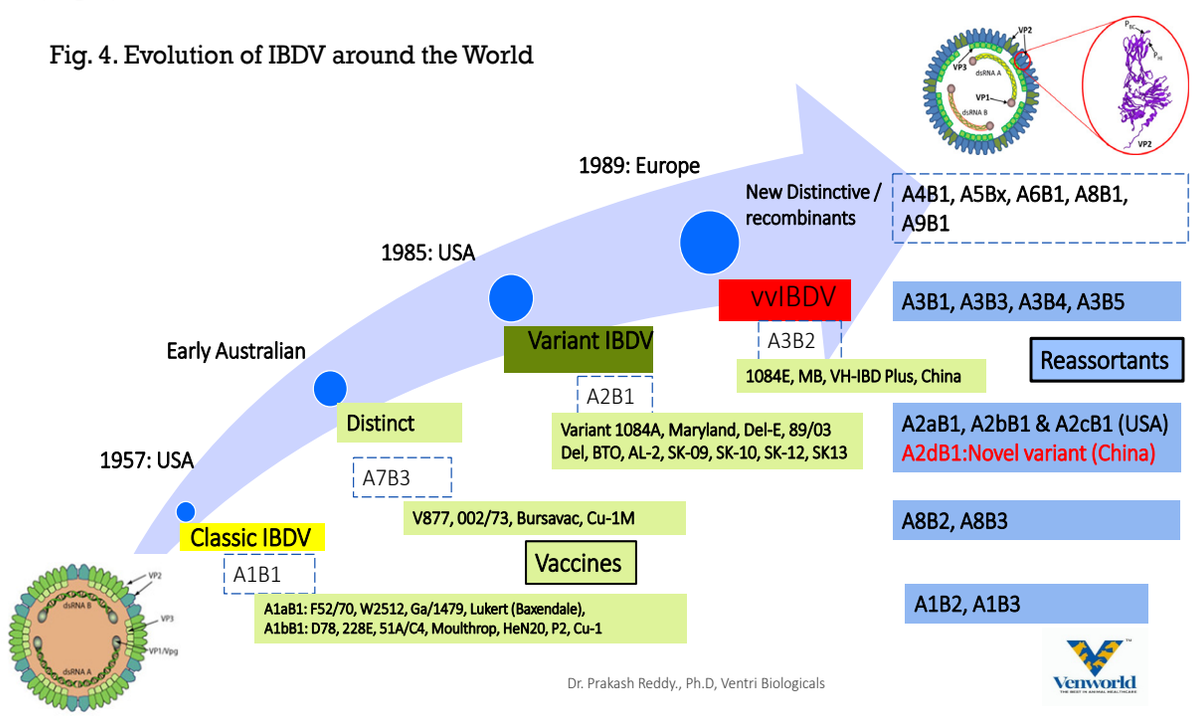
### 7. Immunosuppressive Infectious bursal disease (IBD)

IBD is an immunosuppressive disease of chickens caused by a birnavirus (bi-segmented) and is responsible for many cases of respiratory and enteric disease. IBDVs have been traditionally divided into four phenotypes based on their pathogenicity and antigenicity, including classic, variant, very virulent, and attenuated IBDV. From the mid-1980s, vaccination failures began to be described in poultry operations around the world. The vaccine breakthrough was due to the evolution of antigenically novel strains against which classical IBDV vaccines were not sufficiently protective. Like the newly evolved MDV strains, these very virulent IBD strains cause more severe disease in unvaccinated birds, with mortality rates of up to 60%.

With the emergences of divergent molecular characteristics novel strains are produced by continuous mutations and recombination. Recently, IBDV genotypes are classified based on the molecular characteristics of both VP2 (a viral capsid protein encoded by segment A) and VP1 (an RNA-dependent RNA polymerase protein encoded by segment B) into 'nine genogroups of A' and 'five genogroups of B'. The commonly used phenotypic classifications of classic, variant, very virulent, and attenuated IBDVs correspond to the A1B1, A2B1, A3B2, and A8B1 genotypes of the proposed classification scheme. The novel variant IBDVs including the strains identified in this study were classified as belonging to genotype A2dB1.

Understanding the combination of genogroups is crucial for molecular epidemiology, as it helps track the evolution of the virus, identify new strains, and differentiate between vaccine strains and field strains (Fig.4).

Fig. 4. Evolution of IBDV around the World



Recently, atypical IBD has become an important disease threatening the poultry industry. The main pathogen of which is reportedly the segment reassortment IBDV strain A3B1. Atypical IBD (Novel variant IBDV) is not characterised by obvious clinical symptoms or mortality, but causes severe damage to the central immune organs leading to significant immunosuppression and a decline in production performance. The preliminary molecular biological tests showed that the pathogens were vvIBDV rather than nVarIBDV.

Last decade, witnessed the emergence of genotype A2dB1b, also known as novel variant IBDV (nVarIBDV), in China, N. America to East Asia. Subsequently, it has been responsible for large scale epidemics in South Asia. Infection by nVarIBDV consistently results in severe immunosuppression, but it is subclinical course may hamper diagnosis, impact estimation and control efforts. Comparatively, nVarIBDV does not cause obvious appearance symptoms and death; however, the central immune organ bursa is severely destroyed causing severe immunosuppression in infected chickens and production performance is reduced. It was reported that nVarIBDV could suppress immune responses to vaccines against both highly pathogenic avian influenza and Newcastle disease, the two most severe infectious diseases threatening poultry farming. Moreover, coinfection with nVarIBDV and other pathogens may further aggravate damage.

In India, both classical (genogroup 1) and very virulent (vvIBDV) or vvIBDV-like strains (genogroup 3) circulating in the country, along with novel reassortant viruses. After the emergence of vvIBDV (A3 genogroup) strains in the early 1990s, the disease has become widely prevalent throughout India, causing high mortality in the affected flocks. Several studies suggest the indigenously developed IBDI+ vaccine clustered with the vvIBDV strains from India, suggesting a similarity to these strains; hence, it is more effective in protecting the flocks against vvIBDV outbreaks compared with other conventional IBD vaccines. Last decade noticed emergence of Novel very virulent variants from A3 genotypes, may be due to the introduction of several vaccine strains into the country which would allow for more circulation of field IBDV and the exchange of gene segments with the different vaccine strains and genetic drift. Widespread use of antigen matched vaccines can reduce viral transmission and population size, consequently reducing the opportunity for viral evolution through genetic mutations and segment reassortment.

**8. Neglected paradox of Infectious bronchitis virus (IBV) in India**

Infectious bronchitis is a severe and acute disease of poultry caused by the infectious bronchitis virus (IBV), similar to SARS/COVID in Humans. The virus is distributed worldwide and primarily infects the respiratory tract, kidneys, and the reproductive system causing respiratory distress, kidney damage, and decrease in egg production.

The emergence of multiple IBV serotypes invariably has hampered control and preventions of the disease. IBV is associated with rapid mutation rates, viral recombination, and host selection pressure. Some IBV genotypes and serotypes are closely related to the vaccines strains while others are variants that are unique to their geographical regions. IBV serotypes show variations in approximately 20–25% in their S1 glycoprotein sequences; however the variation can sometimes be as high as 50%, which affects the cross-protection toward virus strains. Ultimately, viruses that are not 'fit' are eliminated, leaving only fit' ones to strive, spread, and cause devastating disease.

Recently, a S1-gene-based phylogenetic classification of IBV identified six different viral genotypes, 32 distinct lineages, and several unassigned recombinants with inter-lineage origin (Listed in Fig-5). Interestingly, the distribution and diversity of these IBV genotypes differs with geographical location. The global distributions of major IBV serotypes such as Mass-type, 4/91 (793B or CR88)-like, D274-like (D207, D212 or D1466, D3896), and D3128, QX-like, and Italy02. Some serotypes, for example the QX-like IBV, Mass strain from the USA), 4/91 (CR88) from the UK, and the H120 strains from Netherland are variants causing local and regional impacts but with potentials to spread far and wide to other countries.

In India, IBV was first identified in 1967, and the variants were prevalent since 1979. But, in the early 2000s the IBV isolated from the cases of Nephrosis, was reported to have a unique S1 sequence, which according to the recent classification were categorised as Indian indigenous GI-24 lineage. The survey of IBV infection for over two decades from cases of respiratory infections, visceral gout, proventriculitis, gizzard erosions and false layers identified three genetic groups co-circulating in India, of which one group included Mass type of isolates included in GI-1 lineage, which may be live vaccine strain or escape mutants, the second group was 4/91 or 793B type of isolates included in GI-13 lineage, which were related to isolates in China and Europe and the third and most dominant group of isolates were GI-24 lineage (NPR variants) indigenous to India (Highlighted in Fig.5).

These new virus variants do not respond to existing vaccines currently in use. Although some genotypes are restricted to certain geographic regions, others such as Mass, and IBV 4/91 (CR88 or 7/91B) are more global in distribution. Live attenuated vaccines are most often used in the vaccination program; however it is plagued with limitations including poor thermostability, reversion to virulence, and recombination between vaccine and field viruses. As such, these global genotypes can be considered for the development of novel multivalent universal vaccines. However, a regional vaccination strategy based on specific local strains prevalent in the country (GI-24 lineage in India) was adapted in addition to the general vaccines.

**Fig. 5: IBV lineages prevalent in India**

| Lineage | Period of circulation | Prototype strain | |
|---|---|---|---|
| | | Strain name | Country of origin |
| GI-1 | 1937–2013 | Beaudette | USA |
| GI-2 | 1954–2006 | Holte | USA |
| GI-3 | 1960–2006 | Gray | USA |
| GI-4 | 1962–1998 | Holte | USA |
| GI-5 | 1962–2012 | N1/62 | Australia |
| GI-6 | 1962–2010 | VicS | Australia |
| GI-7 | 1964–2012 | TP/64 | Taiwan |
| GI-8 | 1965–1967 | L165 | USA |
| GI-9 | 1973–2011 | ARK99 | USA |
| GI-10 | 1970s–2000s | B | New Zealand |
| GI-11 | 1975–2009 | UFMG/G | Brazil |
| GI-12 | 1978–2006 | D3896 | The Netherlands |
| GI-13 | 1983–2013 | Moroccan-G/83 | Morocco |
| GI-14 | 1984–2006 | B1648 | Belgium |
| GI-15 | 1986–2008 | B4 | Korea |
| GI-16 | 1986–2011 | IZO 28/86 | Italy |
| GI-17 | 1988–1999 | CA/Machado/88 | USA |
| GI-18 | 1993–1999 | JP8127 | Japan |
| GI-19 | 1993–2012 | 58HeN-93II | China |
| GI-20 | 1996–1999 | Qu_mv | Canada |
| GI-21 | 1997–2005 | Spain/97/314 | Spain |
| GI-22 | 1997–2011 | 40GDGZ-97I | China |
| GI-23 | 1998–2012 | Variant 2 | Israel |
| GI-24 | 1998–2013 | V13 | India |
| GI-25 | 2004–2013 | CA/1737/04 | USA |
| GI-26 | 2006–2007 | NGA/B401/2006 | Nigeria |
| GI-27 | 2008–2013 | GA08 | USA |
| GII-1 | 1979–1984 | D1466 | The Netherlands |
| GIII-1 | 1988–2008 | N1/88 | Australia |
| GIV-1 | 1992–2003 | DE/072/92 | USA |
| GV-1 | 2002–2008 | N4/02 | Australia |
| GVI-1 | 2007–2012 | TC07-2 | China |

Mass type variants

4/91 type variants

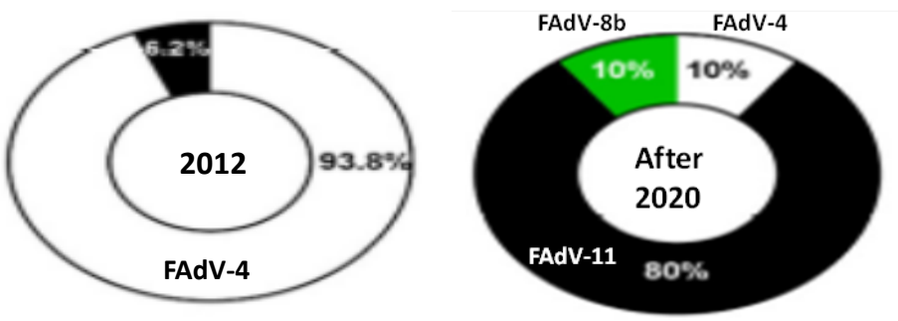
Indigenous Indian variants (NPR)

**9. Low virulent Chicken astrovirus (CAstV) emerging with new problems:**

White chicks hatchery disease is a recently emerged disease affecting broiler chicks and embryos that has been reported in a number of regions worldwide. CAstV infections usually occur within the first days or week of life, transmitted horizontally by the faecaloral route, and some CAstV strains can also be vertically transmitted from naïve in-lay parent birds to embryos; these strains vary widely in pathogenicity and may result in variable clinical manifestations. Losses due to reduced hatchability can be very high, for over a two-week period. CAstVs have been linked to "runting-stunting syndrome" and "uneven flock performance". A runted chick hatches small, while a stunted bird exhibits a failure to grow and often appears to have delayed development. Uneven flock performance occurs when the variance in weights at slaughter is larger than expected, potentially causing carcass processing problems. CAstVs have become associated with hatchery diseases, most notably white chick syndrome, and the chicks that hatch have pale plumage, are weak and runted and tend not to survive very long. Genotypically, based on capsid protein CAstV strains can be clustered into Groups A and B. The Group A CAstVs comprise three subgroups, Ai, Aii and Aiii, and the B group CAstVs comprise six subgroups, Bi, Bii, Biii, Biv, Bv and Bvi. In India, Subgroup Biii is associated with visceral gout, and subgroup Biv is associated with white chick syndrome.

**10. Changing Dynamics of Fowl Adenovirus**

Fowl adenoviruses (FAdV) are becoming dangerous viral threats for the poultry industry in many regions in the world such as North America, Europe, Asia (including India) and the Middle East with a diverse group of viruses affecting chickens. Currently, there are twelve known serotypes of fowl adenoviruses on the basis of cross-neutralization tests. Several outbreaks were reported in many Asian countries such as Iraq, India, Japan, and many other countries. India was endemic for Serotype 4 causing hydropericardium hepatitis syndrome (HPS/HHS) since the late 1990's, but in the last decade there was introduction of FAdV seroytpe 11 and 8. Currently, the low virulent FAdV serotype 11 is endemic, dominating its presence as indicated in the picture below.




FAdVs can become opportunistic pathogens especially in case of concurrent infections, severely affecting the health of affected birds. Some strains of FAdV can be pathogenic in immunocompromised hosts as in Chicken infectious anaemia (CIAV) or infectious bursal disease (IBD) or Mycotoxicosis affected birds. Clinical and gross pathological findings in mixed infections involving infectious bronchitis (IB), Mycoplasma and FAdV can be similar to Infectious laryngotracheitis. The active role of FAdV in causing respiratory disease complex in flocks infected with more than two respiratory pathogens could not be ruled out. The non-infective immunosuppressive factors, such as mycotoxins, stress, and metabolic disease, should be considered before concluding the diagnosis.

**11. Regional Vaccinal laryngotracheitis**

The evolution of infectious laryngotracheitis virus (ILTV) in India has been shaped by the *use of illegal import of live vaccines*, which led to vaccine-derived outbreaks, since 2008 and spread across some of the south Indian states. Studies have shown that vaccine-like viruses, particularly those resembling CEO (chicken embryo origin) vaccines, have circulated and caused outbreaks, with one study identifying such strains as the cause of 2019-2020 outbreaks in Tamil Nadu. The illegal use of imported vaccines from different countries creates a risk of recombination between the vaccine viruses and local field strains, which can complicate outbreak management. Safer and more effective vaccines are needed to prevent both ILT and potential recombination events.

**12. Mycoplasma and Salmonella infections of the persistent carriers:**

The primary challenges in controlling Mycoplasma and Salmonella in the poultry industry stem from the pathogen's inherent biological complexities (intra-cellular pathogens, , carriers for life, vertical trasmission), the limitations of current control measures (like antimicrobial resistance), and the complexities of modern poultry production systems (multiage).

Mycoplasma lacks a cell wall, rendering common antibiotics like beta-lactams (penicillin, etc.) completely ineffective. While specific antibiotics (macrolides, tetracyclines, quinolones) can alleviate clinical signs and reduce transmission, they cannot eliminate the infection entirely, and their overuse contributes to antimicrobial resistance.

There are over 2,500+ Salmonella serotypes, with varying pathogenicity and responses to control measures. New serotypes or variants with enhanced resistance can emerge over time, complicating control strategies that often target specific common serotypes.

The most significant future challenge in controlling both pathogens is the necessity for an **integrated, multi-hurdle approach** across the entire farm-to-table continuum, involving constant surveillance, strict biosecurity, effective vaccination, and the development and consistent application of non-antibiotic alternatives (like probiotics, prebiotics, and bacteriophages) to combat antibiotic resistance and persistent environmental contamination.

**13. Vaccines are not evolution-proof**

The vaccines can provoke and even be overcome by pathogen evolution, by reducing the number of fully susceptible hosts in a population. The competing pathogen strains depends on the immune status of their host, changing immune profiles of a population will prompt pathogen evolution. Most obviously, vaccines that target a subset of strains can give a competitive edge to those not present in the vaccine. But even in the absence of strain-specific effects, widespread vaccination can alter the immune pressures the pathogen's experience. In extreme cases, vaccines can even be the main or only source of pre-existing immune selection.

Naturally acquired immunity will often have little impact on pathogen evolution, partly because major efforts are made to prevent natural infections in the first place, but mostly because animals are slaughtered before natural immunity has time to build up in the host population. When epidemics do occur, vaccine-induced immunity will be a major source of immune selection on the pathogen.

**14. Why has vaccination worked despite evolution?**

Poultry vaccination has successfully managed diseases despite pathogen evolution due to a combination of continuous **vaccine updates, rapid implementation of advanced biotechnology, mass vaccination coverage, and strategic vaccine designs. T**he fundamental practice of mass vaccination with high coverage reduces the overall transmission of the pathogen, limiting the opportunities for the virus to circulate and evolve into new, more dangerous variants.

Generally vaccination prevents disease, but does not prevent infection; rather, it only leads to a reduction in the number of outbreaks. Several factors can lead to the so called vaccine break; incorrect transport and storage of the vaccines, faults or deficiencies of the administration, and high infectious pressure in an area. Also, the reason for not gaining adequate immunity to vaccination could be subclinical infections within the flocks and other immunosuppressive diseases or infections with field strains could occur shortly before or after the vaccination, and/or there could be infections with mutant strains. Finally, the quality of the vaccine is affected by the number of antigens, poor storage conditions, higher concentration of inactivating agents, improper handling and administration.

**15. Strategies that improve the control of evolving poultry pathogens**

a. Biosecurity should not exist as theoretical concepts in books, should be implemented in practice. Strict biosecurity protocols are the first and most cost-effective line of defense against disease introduction and spread.

b. High quality genetic selection to obtain lines and strains with the best performance and resistance, complemented by poultry nutrition to ensure the best production efficiency.

c. Understanding the emergence of pathogens is **critical for designing effective vaccine and control strategies** because it reveals key vulnerabilities, transmission dynamics, and potential immune evasion mechanisms.

d. Introduction of exotic vaccine strains not found in the country/region may further complicate the poultry health for the years to come.

e. The new vaccine technologies open new fields of possibilities for disease controls and disease management, which include genotype based vaccines, vector vaccines, immune complex vaccine etc.

f. These novel vaccine technologies will likely impose completely novel immune pressure or selection for resistance with enhanced immunosuppression and changes in patterns of antigenic variation, tissue tropism, and invasion pathways. There has been little analysis of these possibilities.

g. Innovative **vaccination methods for mass administration with speed and accuracy are fast evolving.** Hatchery vaccination technology like *in-ovo* vaccination of 18$^{th}$ day embryo, semi-automated subcutaneous vaccination in day old chicks, spray vaccination etc. are fast evolving, but the cost, errors or miss outs needs proper evaluation.

h. Antibiotic resistance cannot be stopped, but its spreading can certainly be hindered or delayed with the development of more alternatives with innovative modes of action and a wise and careful use of antimicrobials in a One Health approach.

i. One of the main way the antibiotic residues enter the environment is through poultry waste, which becomes a new environmental reservoir for these genes. Several of these genes are mobile and can move from one species of bacteria to another, creating a more formidable and dangerous setup for humans and animals.

j. Lastly, the pathogens now being targeted are quite different from the organisms responsible for those diseases. A variety of evolutionary responses to vaccination are possible, including the evolution of more virulent pathogens. But, Vaccination is one of the most cost-effective methods of public and animal health improvement. Continuing past successes and realizing the full potential of vaccination requires evolutionary considerations at all stages of vaccine design and implementation.

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# Immunosuppressive diseases of poultry: Challenges and control measures

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## Abstract

Immunosuppressive diseases such as Infectious Bursal Disease (IBD), Chicken Anemia Virus (CAV), and Marek's Disease (MD) continue to challenge global poultry health and productivity. These infections, often subclinical, erode the solid base of immunity required for disease resistance, vaccination response, and overall flock performance. The emergence of IBD and CAV variants worldwide further complicates control measures. This paper highlights the need for integrated immune-base development through strategic vaccination, breeder immunity, and early-life management. It also discusses the molecular evolution of these viruses, their subclinical impacts, and advanced diagnostic and control strategies for maintaining flock immune competence.

## Introduction

The poultry industry's transformation into a highly intensive production system demands uncompromised immune health. Immunosuppression—whether due to infectious (IBDV, CAV, MDV) or non-infectious (mycotoxins, nutritional stress) causes—undermines disease control and profitability. Early immune development, or "solid immunity base," is crucial to protect birds from early-life immunosuppressive challenges.

## Solid Base for Development of Immunity

A strong immunity base begins at the breeder level. Optimum maternal antibody transfer, balanced nutrition (vitamin E, selenium, linoleic acid), mycotoxin control, and stress reduction during early chick life lay the foundation for a robust immune system. Timely vaccination using quality live-killed combinations, supported by seromonitoring, ensures uniform immune priming and booster response. Chicks with a solid immune foundation show better vaccine take, higher resistance to secondary infections, and improved growth performance.

## Subclinical IBD and CAV: Hidden Immunosuppressors

Subclinical infections with IBDV and CAV often go unnoticed but result in lymphoid depletion, poor vaccine response, uneven growth, and secondary bacterial or viral outbreaks.

- Subclinical IBD damages the bursa without obvious mortality, reducing desired level of antibody response to other vaccines like NDV and IB etc.
- Subclinical CAV leads to mild anemia and thymic atrophy, predisposing birds to bacterial infections and poor vaccine seroconversion.

Monitoring maternal antibody levels, real-time PCR screening, and seroprofiling are vital to detect these hidden infections and schedule optimal vaccination timing.

## Global Scenario and Emerging Variants

Worldwide circulation of **variant IBDV strains** (especially vvIBDV and antigenic drift variants

in Asia, Middle East, and Latin America) and **diverse CAV genotypes** complicates immunity and vaccine efficacy. Whole-genome sequencing and phylogenetic studies reveal rapid viral evolution under vaccine pressure. Continuous surveillance and adaptation of vaccines to match local variants are necessary for effective protection.

**Indian Scenario of Immunosuppression**

The Indian poultry industry, being one of the largest and most rapidly expanding globally, faces continuous pressure from **immunosuppressive diseases** that significantly affect flock health and performance. The complex interaction between infectious and non-infectious factors makes immunosuppression a persistent and costly problem across broiler, breeder, and layer operations.

***A. Infectious Causes***

In India, **Infectious Bursal Disease Virus (IBDV)** and **Chicken Anemia Virus (CAV)** are the most frequently encountered immunosuppressive pathogens.

- IBDV: Field outbreaks of very virulent (vvIBD) strains have been reported from all major poultry-producing regions - Maharashtra, Andhra Pradesh, Tamil Nadu, Punjab, and Gujarat. Despite routine vaccination, **subclinical IBD** continues to occur, especially where maternal antibody levels are mismatched with vaccination timing. This results in bursal damage, poor response to NDV/IB vaccines, and susceptibility to secondary bacterial infections such as *E. coli* and *Salmonella*.
- CAV: Serological and molecular evidence indicates widespread circulation of CAV in Indian breeder and commercial flocks, often without clinical signs. Subclinical infections are associated with poor chick performance, reduced livability, and vaccine failure.
- Marek's Disease Virus (MDV): Variant and recombinant MDV strains are increasingly detected, showing lymphoid organ damage even in vaccinated flocks, contributing to overlapping immunosuppressive effects.
- Other agents: Avian reovirus, fowl adenovirus (especially inclusion body hepatitis and gizzard erosion cases), and mixed infections with IBDV–CAV–MDV complexes are commonly seen in diagnostic laboratories, worsening immune breakdown.

***B. Non-Infectious Causes***

Non-infectious immunosuppressive factors are equally significant in the Indian context due to varied climatic and management conditions.

- Mycotoxins: High temperature and humidity favor fungal contamination in feed ingredients, especially maize and soybean meal. Continuous exposure to **aflatoxins and Fumonisins** reduces immune response, suppresses lymphoid organ activity, and predisposes birds to viral and bacterial diseases.
- Nutritional Imbalances: Deficiencies of vitamin E, selenium, and linoleic acid are frequent under practical feeding systems, resulting in oxidative stress and reduced lymphocyte function.
- Environmental and Managemental Stress: High stocking density, heat stress, poor ventilation, and fluctuating brooding temperatures lead to elevated corticosterone levels, impairing immune organ development.

- Water Quality: High microbial load, hardness, and mineral content in farm water further compromise gut and immune health.

**Diagnostic and Control Approaches**

Diagnostic based on histopathology show frequent findings of **lymphoid depletion, bursal atrophy, and anemia** in flocks with low or variable antibody titers, indicating subclinical immunosuppression. Despite widespread vaccine use, **field failures** often arise due to poor timing, stress, or concurrent non-infectious factors. Hence, a **multi-dimensional approach** combining breeder-level vaccination, strict biosecurity, mycotoxin management, stress control, and precision vaccination scheduling is crucial for maintaining a strong immune base under Indian field conditions.

Advanced molecular tools—real-time PCR and sequencing—enable rapid detection and differentiation between vaccine and field strains. Preventive measures include:

- Breeder vaccination for strong MDA transfer
- Monitoring MDA decay and scheduling IBD vaccination (Deventer formula)
- Use of recombinant and immune-complex vaccines for variant coverage
- Feed toxin management and stress minimization

**Conclusion**

Building and maintaining a **solid base of immunity** is the cornerstone of poultry health management. Recognizing and mitigating **subclinical IBD and CAV infections**, understanding **variant evolution**, and implementing **precision vaccination and biosecurity** are essential to overcome immunosuppressive disease challenges and sustain high-performance poultry production.

References – on request

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# Scope of poultry products for Entrepreneurship in Viksit Bharat

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Agriculture, especially poultry farming, is vital for rural prosperity, job creation, and food security. The poultry sector has evolved from small-scale operations into a technology-driven industry, offering numerous entrepreneurial opportunities. The poultry sector in India has evolved from a backyard activity into a modern, organized, and technology-driven agribusiness. As the nation envisions becoming a Viksit Bharat (Developed India) by 2047, the poultry industry offers vast entrepreneurial opportunities that align with goals of nutrition security, employment generation, and rural transformation. The Indian poultry industry is experiencing rapid growth, with a compound annual growth rate (CAGR) of around 8-10% over the past decade. It is the second-largest egg producer globally, producing 142.77 billion eggs, and ranks fifth in broiler meat production with approximately 5.02 million tons in 2023-24. This sector accounts for about 1.5% of India's GDP and directly employs over 3 million people, with millions more engaged in related sectors such as feed production and veterinary services (BAHS, 2024).

India's growing population, rising income levels, and changing dietary preferences are driving a surge in demand for affordable animal protein. Eggs and poultry meat are now recognized as nutrient-dense, accessible, and acceptable protein sources across all regions. Entrepreneurs have a huge scope to cater to this expanding market through innovative products and efficient supply chains. In urban settings, poultry products are viewed as affordable protein sources that are integral to the diets of the middle class. In contrast, rural areas rely on backyard poultry farming as a vital source of stable income and nutritional security for small farmers. However, the industry is confronted with challenges, including high production costs—particularly for feed, which accounts for 60-70% of expenses—outbreaks of diseases like avian influenza, insufficient infrastructure, and fragmented markets, all of which have historically impeded growth. Despite these challenges, the sector's resilience and adaptability, along with supportive government policies, have established it as a key player in enhancing India's agricultural landscape. Within the framework of Viksit Bharat 2047, the poultry industry is well-positioned to boost rural incomes, improve nutritional security, and create jobs across India. As one of the world's leading producers of eggs and chicken meat, this sector has the potential to strengthen India's agri-food economy through modernization, technology integration, and an increase in both domestic and export demand.

## Key Opportunities for Entrepreneurship in Poultry Products

### *1. Poultry Farming*

Establishing commercial poultry farms for broiler chickens and egg layers can effectively meet the increasing demand for affordable sources of protein. By leveraging modern technologies, farmers can optimize production and ensure high-quality products. Furthermore, various farming systems, including contract farming, can be employed by large agribusinesses. In this setup, companies provide chicks, feed, and health services while purchasing the produce from the farmers, making it an appealing option for new and aspiring entrepreneurs.

Currently, there is a noticeable rise in consumer interest in organic and clean-label products, creating substantial opportunities for poultry producers to market ethically raised, chemical-free products, cage-free eggs, and organic chicken. By tapping into this trend, poultry farmers can command higher prices for their offerings. Additionally, groups of farmers or farmer-producer organizations (FPOs) can investigate potential export markets, broadening their reach beyond local sales.

Large-scale poultry entrepreneurs can gain advantages from vertical integration by overseeing the entire value chain, from feed production to processing and marketing. This strategy facilitates cost reduction, quality assurance, and improved profit margins. By manufacturing their own feed, companies can lessen their dependence on external suppliers, and having in-house processing facilities allows them to add value through cutting, packaging, and branding.

***2. Poultry Processing and Value-Added Products***

In India, there is a considerable opportunity to use meat through value-added processing, as the current level of processing into convenient, high-quality products remains quite low. Meat sold in wet markets often suffers from quality issues and contributes to higher post-harvest losses. For instance, chicken meat can be offered in various forms like curry cuts, boneless pieces, breasts, drumsticks, or marinated varieties, which are particularly sought after in urban areas. These value-added products can be supplied to local restaurants, supermarkets, and online platforms. The advantages of adding value to meat are numerous, including the creation of a wider range of products, longer shelf life, improved profit margins, and the creation of new job opportunities. Furthermore, there is an increasing demand for processed meat items such as nuggets, sausages, biryani, and curries. Additionally, India has a diverse range of region-specific ethnic products that can be made using poultry meat, thereby further enhancing market potential. Likewise, chicken eggs are a nutritious output of the poultry industry that can be processed into egg powder and liquid eggs, which are utilized in the food sector.

***3. Quality and affordable feed production***

In poultry farming, a large portion of costs is linked to the purchase of feed, creating opportunities for the establishment of feed manufacturing businesses. High-quality feed is crucial since it directly affects poultry production and has financial implications. The Indian poultry feed market was valued at ₹ 955.3 billion in 2024, and the IMARC Group predicts it will reach ₹ 1,290.7 billion by 2033, with a compound annual growth rate (CAGR) of 3.23% from 2025 to 2033. This growth trend is a positive indicator for entrepreneurs in the poultry feed industry. As traditional feed ingredients continue to rise in cost, there is an urgent need for alternative feed components to lessen dependence on conventional sources and reduce expenses without sacrificing quality. Various alternative ingredients, including insect proteins, algae, and agricultural byproducts, are being actively researched for incorporation into poultry feed. One particularly promising option is black soldier fly (BSF) larvae, known for its high protein content and favourable fatty acid profile, making it an appealing protein source. Several startups in India have started to farm BSF for larvae harvesting, which also aids in waste management. This dual benefit not only helps in waste reduction but also results in the production of protein- and fat-rich larvae. Moreover, there is growing potential for developing customized poultry feed specifically designed for different bird types, considering their growth stages and production goals.

**4. Health, Quality, and Sustainability Trends**

Consumers increasingly seek safe, traceable, and antibiotic-residue-free products. This opens new business avenues in organic poultry production, free-range systems, and welfare-certified farms. Sustainable production models, emphasizing eco-friendly waste management and carbon neutrality, can attract premium markets and export potential. Poultry diseases can lead to substantial losses, highlighting the importance of poultry healthcare in maintaining bird health, preventing illnesses, and ensuring food safety. Biosecurity measures are critical practices aimed at stopping the introduction and spread of infectious diseases within poultry populations. These measures include well-designed facilities, strict hygiene protocols, controlled access to farms, and effective waste management. Together, these strategies work to protect poultry health, improve productivity, and ensure public health and food supply security. Entrepreneurs play a crucial role by offering veterinary services, diagnostic facilities, and biosecurity solutions to address these challenges. In rural areas where veterinary access may be scarce, mobile veterinary clinics with diagnostic capabilities can provide vital on-site consultations and healthcare. In nearby urban areas, disease diagnostic laboratories can enhance disease detection and train farmers in effective disease management. Furthermore, poultry farms will need disinfectants, sanitizers, and protective equipment. With increased focus on disease prevention, the demand for such products is anticipated to rise, especially among large commercial farms.

**5. Diversification Avenues**

The poultry sector offers multiple byproduct-based ventures:

- Feather meal, bone meal, and biogas production from waste utilization
- Pet food ingredients and nutraceuticals derived from poultry proteins
- Cosmetic and pharmaceutical uses of egg derivatives

Such diversification contributes to a circular economy and maximizes value from every component of the production system.

Entrepreneurs can leverage frontier technologies such as:

- Automation and precision feeding systems
- AI-based disease surveillance and smart sensors for flock management
- Blockchain and QR-coded traceability to assure consumers of product authenticity
- Cold chain and logistics innovations to maintain product safety and shelf life

These innovations create a strong interface between traditional farming and modern agribusiness.

**6. Waste Management and Sustainability**

Poultry farming generates significant waste, including manure, feathers, and litter, which can lead to environmental pollution and health hazards if not managed correctly. However, entrepreneurs can turn this challenge into an opportunity by developing sustainable waste management solutions that

effectively address these problems while converting waste into valuable resources. Poultry manure is rich in nutrients and can be converted into high-quality organic fertilizer through processes like composting or vermicomposting. Entrepreneurs can set up composting facilities or small-scale vermicomposting initiatives to produce and market this sought-after fertilizer to farmers, horticulturists, and garden centers. Additionally, poultry litter can be processed for biogas production, which generates methane that can be used for cooking or electricity, while the residual slurry can serve as fertilizer. This approach minimizes waste and provides a renewable energy source for rural communities. Entrepreneurs may also work with the Ministry of New and Renewable Energy (MNRE) to secure subsidies for establishing biogas plants. Furthermore, feathers can be processed to extract keratin, which can be used in animal feed, fertilizers, and biodegradable plastics. By partnering with the textile and cosmetic industries, entrepreneurs can explore and enhance the use of feather-derived products, thereby adding value to this otherwise discarded by-product.

***7. E-Commerce and Digital Marketing***

Poultry farmers, especially those in rural areas, encounter difficulties due to market fragmentation and inequitable pricing. E-commerce platforms and digital marketing tools can help mitigate these challenges by linking farmers directly with consumers, retailers, and processors. Online poultry marketplaces can boost the agricultural sector by enabling farmers to list their products, set prices, and connect with buyers nationwide. New platforms similar to BigHaat and Ninjacart can be created to provide the necessary logistical support for the prompt delivery of fresh poultry products. Mobile applications and websites can offer farmers access to current information on market prices, weather conditions, disease alerts, and effective farming practices. For example, an app that sends notifications about fluctuations in feed prices or alerts regarding avian influenza outbreaks can empower farmers to make well-informed decisions. Entrepreneurs can monetize these apps through subscription services or partnerships with suppliers of farming inputs.

**Government of India Initiatives for promotion of the poultry sector**

The Government of India has implemented several initiatives to improve the poultry sector and encourage entrepreneurship. One of these is the National Livestock Mission (NLM), which focuses on the sustainable development of livestock by providing financial assistance, subsidies, and capacity-building resources for poultry farming and related activities. The Government of India, through initiatives like AHIDF (Animal Husbandry Infrastructure Development Fund), Startup India, and ICAR's research programs, provides a supportive framework for young entrepreneurs. Access to credit, incubation, and mentorship through Krishi Vigyan Kendras and Agribusiness Incubation Centres further accelerates enterprise creation.

The Agricultural Infrastructure Fund (AIF) offers low-interest loans to help establish storage, processing, and marketing facilities. Various states have also developed specific poultry programs, such as subsidies in Tamil Nadu and the provision of training and chicks for women's self-help groups in Punjab. These efforts are aimed at addressing critical issues in poultry farming to ensure long-term resilience in the sector. Overall, these initiatives work together to foster a supportive environment for growth in the poultry industry.

Poultry entrepreneurship has demonstrated immense potential for women's empowerment and youth engagement. Small-scale and cluster-based poultry units can enhance rural livelihoods, strengthen the cooperative model, and contribute directly to Atmanirbhar Bharat.

## Conclusions

In conclusion, the poultry industry extends far beyond just egg and chicken production; it is crucial for generating rural employment, ensuring food and livelihood security, and contributing to economic growth in India. The sector can offer remarkable entrepreneurial opportunities in Viksit Bharat, covering the entire value chain from farming and processing to waste management and digital marketing. With India's on-going urbanization and the growth of its middle class, the demand for poultry products is anticipated to increase, leading to a sustainable market. To capitalize on this potential, entrepreneurs should focus on adopting technology, promoting sustainability, and enhancing value. Collaborating with government initiatives, partnering with agribusiness companies and farmer-producer organizations (FPOs), and being mindful of consumer preferences—like quality, convenience, and ethical practices—will be essential. By investing in this sector, entrepreneurs can play a significant role in transforming India into a developed nation.

The scope of poultry products for entrepreneurship in Viksit Bharat is vast and multidimensional. With innovation, technology adoption, and strong value-chain linkages, the poultry sector can become a key pillar of India's protein security and rural economic growth. Empowering entrepreneurs to capitalize on these opportunities will ensure that by 2047, India's poultry industry stands as a model of efficiency, inclusivity, and global competitiveness. As the saying goes, "Small eggs can lay the foundation for a big future," and in Viksit Bharat, the prospects for poultry entrepreneurship are indeed bright.

## Further Readings

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# Beyond the Shell: Innovations and Opportunities in Egg Processing for Viksit Bharat

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## Egg Production Dynamics

India has emerged as a global leader in egg production, ranking second worldwide after China and closely followed by USA. In the fiscal year 2023–24, the country produced an estimated 142.77 billion eggs, reflecting a compound annual growth rate (CAGR) of 6.87% over the past decade This growth underscores the sector's significant contribution to global food security and nutrition. The per capita availability of eggs in India has increased to approximately 103 eggs per annum in 2024, from 62 eggs in 2014–15 (BAHS, 2024). This development due to various initiatives taken by Govt under programs National Livestock Mission (NLM), Rural Backyard Poultry Development (RBPD), and Animal Husbandry Infrastructure Development Fund (AHIDF) to support layer farming and processing infrastructure. Moreover, it is attributed to This rise indicates a positive shift in dietary habits and consumer acceptance of eggs as a cost-effective, high-quality protein source.

Egg production in India is predominantly concentrated in a few states. The top five egg-producing states—Andhra Pradesh (20.13%), Tamil Nadu (15.58%), Telangana (12.77%), West Bengal (9.93%), and Karnataka (6.51%)—collectively contribute to over 64% of the national output. These regions have per capita availability of eggs more than 250/annum. These regions benefit from well-established poultry infrastructure, favorable climatic conditions, and advanced farming practices.

Historically, egg consumption in India faced cultural constraints due to misconceptions associating eggs with non-vegetarian dietary habits. However, in recent years, there has been a notable shift in perception, with eggs increasingly being accepted as a wholesome, vegetarian-compatible, and affordable source of high-quality nutrition. This growing consumer acceptance, coupled with rising income levels and urbanization, continues to drive the expansion of India's egg industry.

## Why Processing and Value addition to eggs?

The Indian egg market is still dominated by table egg consumption, which accounts for over 90% of total output, with only 2–3% entering organized processing channels (compared with appx. 30% in developed countries like the U.S.). With production outpacing domestic consumption during certain periods, marketing of shell eggs alone is insufficient to absorb the surplus.

Egg processing represents a strategic necessity rather than an optional add-on in India's rapidly growing poultry sector. It serves as a bridge between production and consumption, ensuring economic stability, nutritional security, and market diversification. As India's egg output continues to expand, investment in modern egg-processing infrastructure, cold chain, and product innovation will be critical to achieving both domestic and export-led growth in the coming decade.

*1.* ***Managing Seasonal Price Fluctuations and Surplus Production:*** Egg production in India is largely continuous, whereas consumer demand fluctuates seasonally-particularly declining during the summer months and certain cultural or religious periods. This imbalance leads to price crashes and economic losses for producers. Processing of surplus or off-grade eggs into value-added products (such as liquid, frozen, or dried forms) provides a stable market outlet, helping to stabilize prices and ensure economic sustainability of the sector.

2. ***Reduction of Post-Harvest Losses****:* Due to inadequate cold-chain infrastructure and poor handling practices, shell eggs in India typically have a shelf life of only 7–10 days under ambient conditions, especially in tropical climates. Breakages, microbial spoilage, and loss of internal quality (albumen thinning, yolk flattening) lead to post-harvest wastage estimated at 4–6% nationally.

*3.* ***Utilization of Off-Grade and Cracked Eggs:*** Nearly 8–10% of total production in commercial farms comprises off-grade, cracked, dirty, or misshapen eggs that do not meet retail standards. These eggs, though nutritionally identical, fetch lower prices or are discarded. Egg processing offers a scientifically sound method to utilize such eggs after pasteurization, ensuring value recovery and reducing economic losses and food waste.

*4.* ***Meeting Industrial and Institutional Demand:*** The Indian food-processing, confectionery, bakery, and hospitality industries increasingly demand standardized, microbiologically safe, and convenient egg ingredients.

5. ***Enhancing Food Safety and Quality Assurance:*** Shell eggs are potential carriers of pathogenic microorganisms, especially *Salmonella enteritidis*. The conversion of eggs into pasteurized liquid or dried products eliminates major microbial risks, ensuring safety for industrial and consumer use.

*6.* ***Facilitating Export Potential:*** There is immense potential to export value-added egg products rather than just shell eggs. Processed egg products — especially whole egg powder, albumen powder, and yolk powder — are in high global demand due to long shelf life, lower freight cost, and easy reconstitution.

7. ***Employment, Entrepreneurship, and Rural Livelihoods:*** Egg processing units, including small-scale enterprises producing pickled, salted, or powdered eggs, create rural employment opportunities, especially for women and youth. Institutions such as GADVASU, Ludhiana and ICAR-Central Avian Research Institute (CARI), Izatnagar, have developed low-cost egg-based technologies suitable for small entrepreneurs, promoting local value addition and income diversification.

***8. Alignment with Government Policies and Food-Processing Vision:*** The Animal Husbandry Infrastructure Development Fund (AHIDF), PM Formalisation of Micro Food Processing Enterprises (PM-FME), and National Livestock Mission (NLM) emphasize egg processing as a priority area for investment. These programs promote infrastructure for egg grading, breaking, pasteurization, drying, and packaging, positioning India as a competitive player in the global egg-processing industry.

9***. Sustainability and Resource Efficiency:*** Egg processing contributes to sustainable utilization of resources by minimizing food waste through efficient use of surplus eggs and reducing carbon footprint per unit of usable protein (via extended shelf life and efficient logistics). Further it supports the

development of functional and fortified egg products (e.g., omega-3, vitamin-enriched) that enhance public nutrition without increasing resource inputs.

A sustainable solution to stabilize prices for off-grade or unsold eggs is their conversion into value-added egg products. Such products include liquid, frozen, or dried eggs, collectively referred to as "egg products," which are removed from the shell and processed for industrial or retail use. Processed egg products are widely used for their functional roles as natural binding, foaming, emulsification, and thickening products, offering uniform quality and food safety. Industrial processors standardize these traits for dependable use in diverse formulation systems like baked goods, pasta, and salad dressings.

**Advantages:** There are *tangible direct, quantifiable benefits*

**Extended Shelf Life:** Processed eggs (liquid, powdered, frozen) than fresh eggs, so reduces spoilage and waste during transport and storage.

**Improved Safety & Hygiene:** Pasteurization during processing kills harmful pathogens like *Salmonella*. Lower risk of foodborne illnesses compared to raw shell eggs.

**Convenience for Food Industry:** Ready-to-use forms like liquid or powdered eggs simplify operations for bakeries, restaurants, and food manufacturers. Therefore, save time and labour cost on cracking, separating, and measuring eggs.

**Standardization:** Processed eggs offer consistent quality in terms of weight, yolk-to-white ratio, and composition. Essential for maintaining product uniformity in large-scale food production.

**Economic Value-Addition:** Converts surplus or cracked eggs (unsellable as fresh shell eggs) into usable products. Increases profit margins and reduces waste at the farm and processor level. producers can achieve **uniform pricing**, minimize wastage, and improve profitability.

**Better Storage and Transport Efficiency:** Powdered eggs are lighter and less fragile than fresh eggs. Easier and cheaper to store and ship internationally.

*Intangible Advantages (Non-Measurable or Indirect Benefits)*

**Brand Reputation & Trust:** Bakeries/Companies using safe, consistent egg products build customer trust. Processed egg suppliers known for quality gain market credibility.

**Environmental Sustainability:** Reduces food waste by utilizing all grades of eggs. Efficient packaging and transport reduce the carbon footprint compared to fresh egg logistics.

**Innovation & Product Development:** Enables creation of new food products (e.g., protein bars, meal replacements, specialty baked goods). Flexibility in formulations helps R&D teams innovate faster.

**Support for Global Food Security:** Shelf-stable egg products can be exported to regions without reliable cold chains. Important for disaster relief, military rations, and school feeding programs.

**Regulatory Compliance:** Processed eggs meet food safety regulations more easily than raw shell eggs. Ensures access to export markets with strict food import laws.

Overall, value addition not only enhances food safety and shelf life but also strengthens the economic viability of the poultry and egg sector, making it a critical component of modern egg production and processing systems.

**Present Status of Egg Processing**

Global egg processing market is expanding steadily, valued at about USD 39 billion in 2025 and projected to reach between USD 53 and 58 billion by 2030–2032 at a CAGR of 5–6%. Egg processing in India is transitioning from a nascent to a growth phase within a global market that is becoming increasingly technology-driven and diversified. India's rising production and export competitiveness position it to play a major role in the next decade's processed-egg supply chains.

India's egg processing sector is dominated by a handful of integrated players producing pasteurized liquid, frozen, and spray-dried egg products, mainly catering to the baking, confectionery, and export sectors. The combined installed national egg processing capacity in 2025 is estimated around 4–5 million eggs per day, though less than 1.5% of India's overall egg output is industrially processed-signaling strong growth room for value-added processing infrastructure.

Despite the growth in value-added egg products, the Indian egg processing industry faces challenges such as inadequate cold chain infrastructure, which leads to significant post-harvest losses. According to a 2023 report by the Central Poultry Development Organization, nearly 15% of egg production is lost due to spoilage, particularly in rural areas. Addressing these infrastructure gaps presents an opportunity for further growth in the processing sector.

The trend towards value addition in India's egg industry is a strategic response to market challenges and consumer demands. By investing in processing technologies and infrastructure, India can enhance the shelf life, safety, and marketability of its egg products, thereby strengthening its position in both domestic and global markets.

**Major Egg Processing Companies in India (2025)**

- SKM Egg Products Export (India) Ltd, Erode, Tamil Nadu Over 1.8 million eggs/day
- Ovobel Foods Ltd. Bengaluru, Karnataka 1 million eggs/day
- Taj Agro Products Mumbai, Maharashtra; 0.5 million eggs/day
- Eggway International Asia Pvt. Ltd. Hyderabad, Telangana; 0.3 million eggs/day
- Nature-Egg LLP Gurgaon, Haryana; 50,000eggs/day
- Reina Industries Pvt. Ltd, Gurgaon, Haryana; 50,000eggs/day
- Peggs India Pvt Ltd, Rajpura, Punjab ; 50,000 eggs/day

**Industry Milieu**

- The Indian egg powder market value in 2025 is USD 50.7 million, projected to grow to USD 64.8 million by 2031 at a CAGR of 4.16%.
- Processing is concentrated near high-production belts (Namakkal, Erode, Bengaluru, Hyderabad, and Ludhiana).

- Capacity utilization remains modest (~60–70%) due to raw egg price fluctuation and limited domestic demand, but exports to GCC and Japan are expanding steadily.
- Smaller technology-driven brands like Henfruit and Eggoz Nutrition are introducing automation and antibiotic-free liquid egg concepts for retail urban segments.

**Regulatory Framework:**

Egg processors in India must meet national and export-level regulatory certification requirements to ensure food safety, quality control, and international trade compliance. These certifications are overseen primarily by FSSAI, APEDA, and the Export Inspection Council (EIC) under the Ministry of Commerce.

**1. FSSAI License and Compliance:** All egg processing units operating within India must obtain a **Food Safety and Standards Authority of India (FSSAI)** license under the *Food Safety and Standards (Licensing and Registration of Food Businesses) Regulations, 2011*.

- Requirements: Good Manufacturing Practices (GMP), Good Hygienic Practices (GHP), sanitation, residue testing, and traceability systems.
- Additional compliance includes product standards for egg-based food additives and hygienic handling under FSS (Food Products Standards and Food Additives) Regulations.

**2. HACCP-based Food Safety System Certification:** Most large processors are required to implement a Hazard Analysis and Critical Control Point (HACCP) plan covering entire operations—from sourcing shell eggs to pasteurization, drying, and packaging.This is mandatory for both domestic high-risk food processing and export-oriented operations.

**3. ISO/FSSC Certifications (Industry Good Practice):** Many plants voluntarily maintain ISO 22000 or FSSC 22000 certification covering integrated food safety management systems, recognized globally for compliance equivalence.

**Export Certifications (Mandatory for Export-Oriented Units)**

1. **EIC/EIA Approvals:** The Export Inspection Council of India (EIC) grants mandatory approval for establishments exporting egg products as per the *Export (Quality Control and Inspection) Act, 1963*, and GOI Notifications S.O. 2077 & S.O. 2078 (dated 4.8.1997).

- The approval process includes structural assessment, HACCP validation, residue monitoring, and traceability audits.
- Only EIA-approved establishments are permitted to export egg powder, frozen egg, or liquid egg products.

**2. Export of Egg and Egg Products (Quality Control, Inspection, and Monitoring) Rules, 2021:** These rules prescribe mandatory testing for microbiological, antibiotic, pesticide, and heavy metal residues before export approval.

- Export Inspection Agencies (EIAs) issue health certificates after compliance verification.
- Plants pay inspection and monitoring fees (0.2% of FOB value, capped at ₹25 lakhs per annum).

**3. APEDA Registration (RCMC):** Every exporter of egg products must obtain a Registration–cum–Membership Certificate (RCMC) from the Agricultural and Processed Food Products Export Development Authority (APEDA), which manages India's egg export registration through its ERP portal.

- APEDA also coordinates quality promotion, capacity building, and assistance under Agri Export Policy programs.

**Optional/Global Certifications (for Export Competitiveness)**

- **EU Listing/Approval**: For exports to the European Union, facilities must meet **EU Directive (EC) No. 853/2004** standards, validated through EIC inspection.
- **Halal and Kosher Certification**: Required for export to Middle East and Israel markets, certifying the product's compliance with dietary standards.
- **Organic Certification (NPOP/NOP)**: For premium organic egg products intended for niche markets, approved under the National Programme for Organic Production (NPOP) of APEDA.

**Table: Minimum Requirement of Composition for Liquid Egg Products (FSSAI, 2016)**

| Composition | Liquid egg white | Liquid egg yolk | Liquid whole egg |
|---|---|---|---|
| Min solids matter content (%) | 10.5 | 40.0 | 22.0 |
| Min fat content (%) | 0.05 | 25.0 | 9.8 |
| Min protein content (%) | 10.0 | 15.0 | 10.5 |
| Extraneous matter | No particles over 1 mm in 100 g and should not exceed 100 mg/kg | No particles over 1 mm in 100 g and should not exceed 100 mg/kg | No particles over 1 mm in 100 g and should not exceed 100 mg/kg |
| Min. concentration of hydrogen ions (pH) | 8.5 | 5.9 | 7.0 |
| Max. β-hydroxybutyric acid (mg/kg) | 10 | 10 | 10 |
| Max lactic acid (mg/kg) | 1,000 | 1,000 | 1,000 |
| Max succinic acid (mg/kg) | 25 | 25 | 25 |

**Liquid whole egg**: As soon as the eggs are broken, the liquid egg must be pasteurized to reduce the possibility of contamination and proliferation of food borne pathogens such as *Salmonella*. As per the USDA, it is required that liquid whole egg must be heated to at least 140˚F and held for no less than 3.5 min, or at least 134˚F and held for no less 3.5 min, or at least 132˚F and held for 6.5min for egg white. Additives such as sucrose, glucose or fructose or salt may be added at 10% level to protect heat damage. The solid content of liquid egg is usually standardized to 43-44% and the pH of liquid whole egg may vary from 7.0 to 7.6.

UHT treatment of liquid egg requires higher temperature for a shorter period of time. Usually, eggs are heated to a temperature of 70˚C for 1.5 min, the aseptically packaged final products can have a shelf life of 24 weeks under refrigerated condition. Many functional ingredients such as omega-3 PUFA, lutein, vitamins and minerals can be used to enriched and make a functional food.

The global liquid egg market has shown robust growth, with projections indicating an increase from USD 5.5 billion in 2024 to USD 5.84 billion in 2025, reflecting a compound annual growth rate (CAGR) of 6.1%. In India, the liquid egg segment is gaining traction due to its convenience, longer shelf life, and reduced labor costs associated with shell-breaking. These products are increasingly utilized in the foodservice and bakery industries, as well as in export markets.

**Dehydration/ egg powder**: Egg powder is one of the most common products in poultry industry in the country. Transportation of eggs is difficult as chances of breakage during transportation are higher and it is costly also. Egg powder is comparatively easier to transport and there is no question of any breakage during the transit. The major market is defense exports, establishments, various government and non-government nutritional programmes, bakeries and all such areas like hills or forests where transportation is difficult.

Removal of moisture from liquid egg after pasteurization results in efficient storage and transportation, and they are easy to handle and to formulate. Different drying methods can be used to accomplish the drying although spray drying is the most common method and the flowability in the product can be achieved by adding a free-flowing agent such as sodium silicoaluminate or silicon dioxide. It is required that the finished dried product must contain not less than 95% total egg solids by weight (FDA,2012). The egg liquid must be desugarised before drying either by yeast or bacterial fermentation to prevent Maillard reaction during drying. It has been reported that 40% of the export of poultry products comprise of egg powder, Japan being the being the largest buyer followed by Germany and Indonesia.

***Flowchart for the production of whole egg/ egg yolk powder***

Whole eggs or egg yolk: Homogenization

↓

Filtration: to remove membranes and fragments of shell pieces

↓

Pasteurisation @64-66˚C/ 2-4 mins

↓

Spray drying

↓

Whole egg/ egg yolk powder (moisture: 2-4%; bulk density: 0.3-0.35g/cm$^{3)}$

The egg powder market in India was valued at approximately USD 50.72 million in 2025 and is expected to reach USD 64.79 million by 2031, growing at a CAGR of 4.16%. Egg powder offers advantages such as extended shelf life, ease of storage, and suitability for export, making it a preferred choice for both domestic and international markets.

**Refrigerated/Frozen egg products:** The white and yolk of an egg is pasteurized separately to destroy *Salmonella* and other bacteria and kept frozen or under refrigeration to increase its shelf life. The liquid eggs are kept under refrigeration at a temperature 40˚F (4˚C) or below, and frozen products are stored at 0˚F (-17˚C). The frozen egg products must be thawed at refrigeration temperature for 2-3 days before use, and must be used within 4-5 days once thawed. These frozen and liquid may be further used in bakery industry or other in fast food outlets.

Frozen egg products are also witnessing growth, driven by their convenience and versatility in various culinary applications. While specific market size data for India is limited, the global egg processing market, encompassing frozen products, is projected to reach USD 41.9 billion by 2029, growing at a CAGR of 4.7%. India's participation in this segment is expected to increase as domestic processing capabilities expand.

**Ready-to-eat Processed Egg Products:** Liquid egg, egg powder and frozen egg products being produced at large quantity in industrial scale. But beside these products, several other convenience or processed form of eggs are also being produced; specialty egg products such as egg crepes, egg rolls, egg omelets, scrambled eggs, quiches and others. Research on egg and egg products has been going on widely in Department of Livestock Products Technology, GADVASU and ICAR-CARI, Izatnagar. Several products are developed and technologies are already transferred to entrepreneurs. Some of the technology developed in the same are discussed further.

**Egg Jam:** Jam is a nutritious and tasty product liked by the kids is mainly prepared from fruits. It has high sugar content and no protein content. Egg jam is developed from whole egg liquid and is considered as tastier, sweet with excellent spreadability. It is a superior nutritive alternative to fruit-based jams in market. Egg jam contains high biological value protein (14-16%), contains all essential amino acids and fatty acids. Various flavoured egg jams such as Mango, pineapple and plain were developed. Diabetic egg jam or high protein, sugar free egg jam was also developed.

**Egg chutney:** It is a whole egg liquid product that us sweet, salty and tangy in flavor similar to fruit-based chutney and has a protein content of about 15-17%. The product is free from artificial color and flavor and can be stored at refrigeration temperature for up to 6 months.

***Egg cutlets:*** It basically is a novel product obtained by uniform mixing of whole egg liquid and mashed potato avoiding the formation of clumps and cooked in a pre-heated oven at 155˚C for 15 min followed by deep frying. Preparation of egg cutlets enable protein enrichment of commercially available fast foods.

***Egg drink:*** Egg drinks are refreshing drink with a protein content of 4-6gm/100ml, fat 2-3g/100ml and energy 68-80 Cals/100 ml, most suitable for summer months. It is prepared by mixing egg drink concentrate and chilled water in the ratio 0f 1:4 and available in six different flavors i.e. mango, banana, lemon, orange, pineapple and coconut.

***Egg parantha:*** It is a ready-to-cook product having protein content of 12-14g, Moisture: 40-43g, Fat: 10-12g. The egg parantha can be stored under frozen condition in laminated pouch with outer aluminium layer and require a cooking time of 3 min (max) prior to consumption.

***Ready omelet mix:*** It is a ready-to-cook product prepared by dehydrating whole egg liquid by mixing with other ingredients. The mixture can be easily mixed with water in 1:3 ration and cook on a hot pan. It is a shelf stable egg product and estimated storage life is 6 months at room temperature.

***Egg Pickle:*** The less desirable small size chicken eggs or quail eggs can be suitably used to prepare egg pickle in the market. The pickle can be stored at room temperature for 1½ -2 months. Two varieties are available in market: vinegar based or oil based.

***Egg Paneer:*** Egg based paneer was developed from whole egg liquid and it is similar in texture to soya and milk paneer. It can be used base material to develop various culinary dishes and various snack-based products. Various varieties such as Egg Albumen paneer free from fat and cholesterol, low calories. It has storage life of 7-10 days at <4ºC under aerobic packaging condition whereas 4week at 4ºC under Vacuum packaging.

**Egg snack products:**

- Albumen rings – made from blended egg-albumen, shaped, battered & fried.
- Egg rolls – filled egg-based snack, shelf-life data provided.
- Egg crepes – thin egg-based wrap/roll filled with vegetables/meat, with refrigerated/frozen shelf-life numbers.
- Egg waffles – crispy snack based on whole egg + flour. Shelf-life at ambient and refrigerated conditions given.
- Egg strips, egg pancakes, egg cutlets etc. for diversified product forms.

**Egg industry by-products**: As egg shell constitutes about 11% of the total egg weight, the main by-product of egg processing plant is the egg shell that can be used to prepare granular egg shell meal and utilized as dietary calcium source for laying hens. Egg shell and egg shell membrane has been widely studied for their efficiency as non-toxic and versatile adsorbents for removal of organic and inorganic hazardous chemicals, especially from waste water. The egg shells having the same chemical composition as lime can be used as plant fertilizers and soil fertilizers. In artistry, the artist uses egg shell for mosaics and texture paints for 3D effects in artwork.

**Conclusions**

Poultry production in India is witnessing a double figure growth rate in the last decade. It has transformed poultry rearing from back yard farming system to the systematic organised poultry industry. This sustained increase is indeed a boon to meet the growing domestic market for eggs and egg products and ensure that India remains self-sufficient in poultry and poultry products. We should analyse the growth in terms of supply, demand and price of egg as well price and buffer stock to maintain the price at consumer and farmer end. This high growth may be only strengthening the oligopolic market power of poultry farmers and/or marketers. The volatile market structure is making poultry farming a high-risk venture. Therefore, the processing of eggs into value added egg products cannot be only a profitable business, but also improves the availability of high-quality protein to the masses. The product market can be divided into ready-cooked egg meals, pasteurized liquid white, liquid egg, hardboiled egg, pasteurized liquid yolk, and dehydrated egg.

# Business opportunities in rural poultry and scope for its expansion in Vikasit Bharat

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Rearing few birds around the house is seen in all most all the areas of Rural India. The birds reared are multicolored, agile with tall legs. The birds fly and run to escape the predators. They live on rooftops & tree branches and are exposed to all types of weather conditions. They are broody in nature and reproduce seasonally. Mother the chicks until they are independent. The owner keeps one of the best male, by looks and few females from the same brood, the number depending on the place available around the house. The birds are given the kitchen leftovers and the low quality grains sorted from the farm produce. The birds scavenge around for green leaves and insects found around the house. The eggs are consumed in the house and few are sold to generate the income. Eggs from few hens, which the house wife feels are good are kept aside in a dark corner for a broody hen to sit and hatch. Few hawkers went around the houses, collected the eggs and carried them to the cities for selling to the urban elite.

**The Rural scene has been changing.**

The land prices are soaring even in rural areas. Availability of land around the house came down from acres to yards and square feet. The road connectivity to villages improved. The electricity power availability has gone up. Clean treated water is supplied to each house through running taps. The house hold expenses have gone up with inflations and the minimum denominations are in hundreds instead of few rupees or a fraction of a Rupee. Education level is up and growing children are exposed to outside the world through internet. The health status is going up and the senior citizens are ready to do some productive work for more years. The house wife is looking for extra income from her leisure time. Animal rearing activity is complementing well with the agriculture. The farmer is already producing grains, milk, flowers and fruits. Why not chicken and eggs?

Rural India is looking up with milk booths to purchase milk, and the weekly markets in every village are set up where the farmers can sell their farm produce directly to the consumer or the trader. With the rise in income, the family is looking for better food and cleaner food. The educated youth, senior citizens and house wives are looking for opportunities for better engagement in productive work and extra earnings.

Research institutes focused at the productivity of the birds and animals living around the house hold. “Low Technology Input birds” are introduced, which are three times more productive compared to the traditional stocks. With the availability of electricity and better connectivity, production of inputs like chicks, feed, vaccines and medicines are well channelized. The health care is improved. The input & output costs and the margins in value addition are being worked out. Government and the private companies are reaching to the remote villages to supply the inputs and purchase the output.

National Livestock Mission encouraged people to rear the better quality chicks in the place of their own chicks, provided inputs and encouraged the urban to buy the rural produce, which is healthier.

Mother units are introduced at many places to supply partly reared and vaccinated birds in the place of one-day old chicks. This development gave opportunity for chicks producing hatcheries, feed suppliers in establishment of the supply chain as an opportunity.

Big poultry production companies encouraged contract farming on" all in all out" basis in the chicken houses built away from each other. The farmers with more land holding took to building chicken houses on their own land, rear larger number of birds, up to 10,000.

The market for the "Low input birds" is catching up with urban elite demanding healthy and farm based products produced under natural farming. The market place expanded for the low input birds. The used up Broiler farms are rearing low input birds independently. The production bifurcated in to meat production and egg production besides the mother units and NLM schemes.

The traditional small cattle sheds are converted to rear Low Input Birds. Continuity in business demands is leading to "cluster forming" run by a group instead of one. This will lead to branding the rural produce with specifications and better margins. Cage free and free range egg farming is being encouraged. Brown egg layers are filling the gap.

# Women Empowerment through Family Poultry for Sustainable Livelihoods

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## Introduction

Empowering rural women has emerged as a central theme in the pursuit of inclusive agricultural growth and sustainable development. Among various livelihood strategies, family poultry production stands out as a low-cost, high-impact intervention that enhances women's income, food and nutrition security, and decision-making power (Panda et al., 2016). As an integral part of smallholder systems in India and other developing nations, backyard or family poultry-characterized by zero input -low output and low input - moderate output, are especially well-suited to the rural poor, particularly women. Women, traditionally the caretakers of poultry flocks, are increasingly being recognized not just as passive participants but as active drivers of rural development. Through capacity-building, improved access to inputs, technologies, markets and institutional support, family poultry can serve as a gateway to gender-responsive livelihood security and empowerment (Panda et al., 2020).

Poultry rearing is an age old practice in India and is an integral part of routine life in rural areas. Small and landless farmers as well as those belonging to weaker sections, including tribal and scheduled castes people traditionally keep local breeds for their subsistence. These birds forage and scavenge for their food in the back yards of human dwellings and provide eggs and meat at insignificant cost. Backyard poultry keeping can be used to reduce poverty among women and children in rural areas. One of the primary objectives of backyard poultry farming in rural India is to provide better income opportunities to the rural poor farmers. Besides, it can address the issues of food insecurity and malnutrition in rural areas and can empower rural women economically and socially (Panda et al., 2010). Of the 17 Sustainable Development Goals (SDGs), also known as the Global Goals, adopted by all United Nations Member States in 2015, backyard poultry production can address the SDG1 (No Poverty- end poverty in all its form everywhere), SDG 2 (Zero hunger- end hunger achieve food security and improved nutrition and promote sustainable agriculture) and SDG 5 (Gender equality- achieve gender equality and empower all women and girls), if implemented properly.

## Family Poultry Production

Family poultry production refers to small-scale, low-cost poultry rearing practiced by rural households using locally available resources and family labor. It typically involves rearing indigenous or dual-purpose birds in a free-range or semi-scavenging system, with minimal inputs for feed, shelter, and healthcare. Managed largely by women, it serves multiple purposes-providing eggs, meat, manure, and a regular source of income. This form of backyard poultry enhances household food and nutritional security, empowers women economically, and acts as a safety net in times of crisis. Family poultry is an accessible, sustainable livelihood option for landless and marginal farmers in rural areas.

**Advantages**

- It is easy to manage and handle.
- It needs minimal use of land, labor and capital.
- It requires little intervention in rearing and management.
- It can easily integrate with other agriculture, aquaculture and livestock farming.
- It can contribute to the village economy.
- It is culturally acceptable and practiced across rural India.
- Women in rural areas can operate family poultry with maximum involvement.

**Role of Women in Family Poultry Production**

Poultry production in the rural areas is generally considered as a key asset for rural livelihoods. Understanding and considering the gender roles in family poultry production is crucial to identifying the most appropriate approach when designing and implementing development activities (Alders and Pym, 2009). Women play a central and multifaceted role in family poultry production, especially in rural and tribal households. Rural women in India have long been associated with backyard poultry keeping. They possess rich indigenous knowledge in bird rearing, feeding practices, brooding, and basic health care. Their roles encompass feeding birds, cleaning shelters, collecting eggs, and even managing small-scale marketing. Time-use surveys have shown that women spend significantly more time on poultry-related activities than men. This labor is often unpaid and undervalued. Despite this, women rarely enjoy decision-making authority over income from poultry sales, which underscores the importance of strengthening their ownership and agency in these systems. Free range and small scale semi-intensive poultry production can be promoted in rural areas to enhance the nutritional status of women and children and also to improve the economic conditions of population in these areas (Pica and Otte, 2010). By increasing women's income, small scale poultry farming also enhances women's social status and decision making power in the household.

**Livelihood and Nutrition Linkages**

- **Income Generation:** Family poultry provides a steady stream of income through the sale of eggs, live birds, and manure. This income, though modest, is more regular and often controlled by women, especially when interventions are designed to be gender-inclusive. Small but regular earnings give women greater financial independence.
- **Nutritional Security:** Eggs and poultry meat are rich in high-quality animal-source protein, essential vitamins (such as $B_{12}$), and minerals (like iron and zinc). An egg supplies about 6.9g wholesome protein of the highest biological value (94). An egg also provides about 6 g fat and is a rich source of linoleic acid, which is essential in human nutrition. Egg contains 44 out of the 45 essential nutrients for the human body. Studies have shown that households engaged in poultry production have better dietary diversity and improved child nutrition indicators (Aklilu et al., 2008).
- **Resilience and Risk Mitigation:** Poultry is an asset that can be easily liquidated (also called as ATM-Any Time Money) during emergencies, making it a form of insurance against shocks like illness, crop failure, or economic downturns. Women's access to such safety nets enhances household resilience.

**Empowerment Dimensions**

The concept of empowerment encompasses access to resources, agency, participation in decision-making, and control over outcomes. Family poultry contributes to empowerment in multiple dimensions:

- **Economic Empowerment:** By engaging in poultry production, women gain access to income and markets. Access to microcredit and self-help groups (SHGs) further strengthens their economic standing. This income often helps women meet personal needs, invest in children's education, or diversify household livelihood options.
- **Social Empowerment:** Participation in producer groups or cooperatives builds social capital. Women acquire skills, enhance their mobility, and become more confident in public spaces. These changes can challenge traditional gender norms and pave the way for broader social transformation.
- **Decision-Making and Agency:** Increased control over poultry-related income translates into enhanced bargaining power within households. Women begin to influence decisions related to household expenditure, children's nutrition, health care, and even family planning.

**Models and Best Practices**

- **Self-Help Group (SHG)-Led Poultry Clusters:** Self-Help Group (SHG)-led poultry clusters are community-based, women-centric models that promote collective production, input procurement, and marketing of poultry products. These models aim to empower rural women economically while strengthening sustainable livelihoods**.** In several Indian states, SHG-based poultry models have proven highly effective. These models integrate women into collective production, input procurement, marketing, and credit services.
- **Technology Support through Livestock Missions**: Family poultry production receives significant technological and infrastructural support through national and state-level livestock development initiatives, particularly under the National Livestock Mission (NLM) and State Livestock Missions. These missions aim to enhance productivity, sustainability, and livelihood opportunities, especially for smallholders and women farmers by providing technical support, vaccinations, and improved breeds (DAHD, 2019). Gender-sensitive extension services that include door-to-door support and women-friendly training modules enhance participation.
- **Public-Private Partnerships (PPPs):** Public-Private Partnerships (PPPs) have emerged as a powerful model to scale up and professionalize FPP by leveraging the strengths of both public institutions and private enterprises. These partnerships enable the delivery of improved technologies, input supply, training, market access, and financial services—especially to marginalized rural women. Partnerships with private hatcheries and feed companies, coupled with NGO support, create value chains that are more inclusive of women. These PPPs help in maintaining supply of chicks, improving market access, and ensuring better prices for products.

**Challenges to Women's Participation and Empowerment**

Despite the opportunities, several constraints hinder women's full participation in poultry-based livelihoods:

- **Access to Assets and Inputs:** Limited access to assets and inputs significantly hampers family poultry production. Without adequate resources like quality feed, vaccines, veterinary care, and

improved breeds, productivity remains low and mortality rates high. Inadequate housing and limited access to extension services further weaken flock health and management. Women, who primarily manage family poultry, often lack access to credit, land, and markets, restricting their ability to expand operations or adopt improved practices. As a result, income generation, food security, and nutrition benefits from poultry remain underutilized. Bridging these gaps is essential for unlocking the full potential of family poultry as a livelihood strategy (Panda et al., 2020).

- **Limited Technical Knowledge:** Limited technical knowledge significantly affects family poultry production by leading to poor management practices, low productivity, and high bird mortality. Farmers lacking skills in feeding, breeding, disease prevention, and housing often struggle to maintain healthy flocks. Without knowledge of vaccination and biosecurity, disease outbreaks become common, reducing flock size and profitability. Inadequate understanding of improved breeds and climate-resilient practices limits productivity. Furthermore, lack of market awareness and business planning skills hinders income generation. Women, who mainly manage family poultry, are disproportionately affected due to limited access to training. Enhancing technical knowledge is vital for improving efficiency, income, and sustainability in family poultry.
- **Market and Mobility Constraints:** Market and mobility constraints faced by women significantly hinder the success of family poultry production. Limited access to transportation, restricted movement due to social norms, and lack of control over income prevent women from selling poultry and eggs at profitable markets. As a result, they often rely on middlemen who offer low prices, reducing their earnings. Poor market information and limited negotiation power further disadvantage them. These constraints also limit access to inputs, training, and services, affecting productivity. Empowering women with better mobility, market linkages, and decision-making authority is essential to enhance income, food security, and sustainability in family poultry systems.
- **Health and Biosecurity Risks:** Health and biosecurity risks significantly impact poultry production by increasing vulnerability to diseases, leading to high mortality and reduced productivity (Bagnol, 2009). Poor sanitation, lack of vaccination, and inadequate housing expose birds to infections like Newcastle disease and avian influenza. Sick birds produce fewer eggs and grow slowly, reducing household income and food security. Frequent disease outbreaks also result in economic losses due to treatment costs and loss of market access. Additionally, poor biosecurity can lead to zoonotic diseases, posing risks to human health. Strengthening health management and biosecurity measures is crucial for sustainable, safe, and profitable poultry production.

**Strategies for Strengthening Women-Centric Poultry Systems**

To realize the full potential of family poultry in empowering women, a multi-pronged strategy is needed:

- **Capacity Building and Gender-Sensitive Training:** Capacity building and gender-sensitive training can significantly improve family poultry production by equipping both women and men with the knowledge and skills needed for efficient poultry management. Extension systems must deliver inclusive, context-specific, and locally translated training modules tailored to women's literacy levels and schedules. Gender-sensitive approaches ensure that women-who are primary

caregivers of poultry-gain equal access to information, decision-making, and resources. Training must cover:

- Improved feeding and housing
- Chick management
- Vaccination and disease control
- Marketing and value addition

- **Access to Finance and Productive Assets:** Access to finance and productive assets plays a crucial role in improving family poultry production. With financial support, households can invest in quality feed, improved breeds, proper housing, and veterinary care, leading to healthier birds and higher productivity. Credit facilities enable farmers-especially women-to expand operations, adopt modern technologies, and manage risks effectively. Microfinance institutions and SHGs should prioritize poultry entrepreneurs for asset-building loans and working capital. Access to revolving funds, subsidies, and risk insurance schemes can reduce entry barriers.

- **Breeding and Input Supply Chains:** Ensuring timely supply of quality chicks (dual-purpose, low-input breeds like Vanaraja, Gramapriya), feed, and vaccines through women-managed hatcheries or SHG-led distribution hubs is crucial. A reliable supply of quality inputs-such as feed, vaccines, and equipment-supports better bird health and farm productivity. Strengthening these supply chains reduces dependency on unreliable local sources and minimizes production costs and losses. It also ensures timely availability of critical resources, enabling smallholders to maintain consistent production. For women poultry keepers, improved input access empowers them to scale operations and increase income.

- **Digital and Market Linkages:** Mobile platforms can provide real-time advisory services, market price updates, and e-commerce options. Digital and market linkages significantly improve family poultry by enhancing access to information, services, and markets. Digital tools help farmers-especially women-gain real-time updates on prices, disease alerts, weather, and best practices, leading to informed decision-making. Linking women to institutional buyers, cooperative federations, and digital platforms can bypass exploitative middlemen. By bridging information and market gaps, digital and market connectivity boosts productivity, income, and resilience in family poultry systems.

- **Policy and Institutional Support:** Policies that explicitly recognize women as farmers and livestock keepers are essential. Livestock missions should earmark funding for gender-inclusive programs. Women's cooperatives should be prioritized for infrastructure development like mini-hatcheries and feed mills. Supportive policies can ensure access to credit, subsidies, quality inputs, and veterinary services (Singh, 2015). Institutional frameworks help coordinate extension services, training programs, and market infrastructure tailored to smallholders, especially women. Policies promoting women's ownership of assets and inclusion in decision-making empower them economically. Institutional backing also facilitates research, innovation, and public-private partnerships.

**Future Directions and Recommendations**

- **Scaling Up Gender-Inclusive Models:** Successful models must be scaled up through convergence with national programs like the Rashtriya Krishi Vikas Yojana (RKVY), DAY-NRLM, and ICAR-CIWA initiatives.
- **Building Resilience to Climate Change:** Poultry systems must be made climate-smart by promoting resilient breeds, heat-protective shelters, and early-warning systems for disease outbreaks. Women should be included in climate-resilience planning.
- **Youth and Women in Agri-Entrepreneurship:** Combining poultry production with value-added enterprises can attract youth and enhance returns. Skill development and entrepreneurship training must prioritize rural women.
- **Gender Mainstreaming in Research and Extension:** Research institutions should prioritize gender-disaggregated data, participatory research with women poultry keepers, and inclusive extension models. More women livestock extension workers should be trained and recruited.

**Conclusion**

Family poultry offers a practical, scalable, and gender-sensitive pathway for rural women to achieve economic independence, improved nutrition, and social empowerment. When backed by inclusive policies, institutional support, and community engagement, it can transform the lives of millions of women while enhancing household resilience and rural development. The empowerment of women through poultry is not just a matter of increasing productivity, it is about investing in the agency, dignity, and leadership of women as key stakeholders in agriculture and development. Strengthening their role in family poultry is an investment in a more equitable and sustainable future.

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# Importance and significance of diversification of poultry in new India

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## Abstract

Among all livestock-based industries, poultry has remained at the forefront of technological advancement, contributing significantly to both the Indian and global economies. Commercial chicken production continues to dominate the poultry sector, supplying nearly all of the white meat and table eggs consumed. As reported in the 20th Livestock Census, the organized poultry industry-largely centred on chicken-accounts for the major share of India's poultry output. However, the nation's agricultural framework is primarily composed of small, marginal, and landless farmers who face intense competition from large-scale commercial enterprises in this high-volume, low-margin industry. To ensure long-term sustainability and equitable growth, it is crucial to promote diversification within the poultry sector by including non-chicken species such as quail, turkey, ostrich, waterfowl, and guinea fowl. Implementing safe and efficient nutritional strategies will be essential as consumer demand for poultry products continues to rise. These alternative poultry species hold considerable promise for the future, as they are well-suited to local agro climatic conditions and thrive in resource-based backyard farming systems. Despite extensive research on chickens, there remains a notable information gap regarding the production, management, and potential of these alternative species in India. This paper aims to bridge that gap by highlighting the present scenario of poultry diversification, its importance and economic value in emerging India, and the challenges and opportunities associated with developing a diversified poultry sector.

**Keywords:** Diversified poultry; Duck; Quail; Turkey; Guinea fowl; Emu

## Introduction

India, with a population of 1.46 billion projected to reach 1.70 billion by 2060 (United Nations, 2023), faces rising demand for food and protein security. Among livestock sectors, poultry is the most dynamic, contributing about 40% of global meat production (FAO, 2023a). In 2024, global poultry meat output reached 140 million tonnes, with India ranking fifth (5.10 million tonnes, 4.5% share). Egg production has also surged by 150%, placing India second worldwide with 142.77 billion eggs annually (BAHS, 2024). India's poultry growth is driven by population expansion, higher incomes, and urbanization, supported by minimal religious restrictions on poultry consumption. The industry has evolved from backyard rearing to a major agribusiness, achieving 6–8% annual growth in egg and 8–10% in broiler production through improved genetics, nutrition, and management (BAHS, 2024). Contributing 11% to agricultural GDP and over 1% to national GDP, India's poultry population reached 851.81 million in 2019, dominated by chickens (94.84%), with ducks (3.94%) and other species (1.22%) forming minor shares (20th Livestock Census, 2019).

However, heavy dependence on commercial chicken production increases vulnerability to disease and market shocks. To achieve sustainable growth aligned with New India's goals of nutritional security, rural empowerment, and self-reliance (Atmanirbhar Bharat), diversification is essential. Integrating ducks, quails, turkeys, guinea fowl, and native chicken breeds into mainstream systems can strengthen resilience, enhance productivity, and position India as a globally competitive and inclusive poultry producer.

**Concept of Sustainable poultry farming**

The concepts of "sustainable development" and "sustainability" are multifaceted, especially within agriculture and the global food system (Vaarst et al., 2015). The FAO defines sustainable agricultural development as the management of resources, technology, and institutions to meet present and future human needs while preserving natural assets (FAO Council, 1989). It must be environmentally sound, socially equitable, economically viable, and technically feasible. In poultry production, sustainability involves balancing environmental stewardship, economic profitability, and social responsibility. Environmentally, it emphasizes reducing ecological footprints through efficient resource use, waste management, and ecosystem conservation. Economically, it ensures profitability, resilience to market fluctuations, and long-term viability. Socially, it upholds ethical labor practices, animal welfare, and community well-being (Bist et al., 2024).

True sustainability recognizes the interdependence of these pillars—progress in one should not undermine another. As challenges like climate change, resource scarcity, and shifting consumer preferences intensify, adopting sustainable poultry systems becomes imperative (Jez et al., 2011; Bist et al., 2024). Poultry diversification emerges as a key strategy, reducing dependence on a single species or market, aligning production with local ecologies (e.g., ducks in wetlands, turkeys in free-range systems), and creating additional income sources—thereby strengthening sectoral resilience and contributing to national growth.

**Poultry Diversification**

Commercial poultry farming in India is a highly organized and capital-intensive industry that depends on strong infrastructure, advanced technology, and strict biosecurity measures to ensure profitable broiler and layer production. However, this high-volume, low-margin model limits the participation of small and medium-scale backyard farmers, who struggle to compete with large commercial enterprises. Consequently, diversification of poultry farming has emerged as a vital strategy to promote inclusivity and sustainability (Prabakaran et al., 2020; Aruna and Anand, 2023).

Poultry diversification can be broadly categorized into four key forms:

(a) Species diversification – rearing alternative poultry species such as ducks, quails, turkeys, guinea fowls, pigeons, geese, emus, and ostriches.

(b) Breed diversification – promoting native and improved chicken breeds adapted to specific local environments and production niches.

(c) System diversification – adopting diverse production models such as backyard, semi-intensive, organic/free-range, and integrated rice–duck or scavenging systems.

(d) Product/value-chain diversification - developing multiple poultry-based products and by-products, including meat, eggs, manure, feathers, and processed or specialty goods, along with robust market channels (Bhadauria et al., 2015).

Diversified poultry systems offer promising livelihood opportunities for small and marginal farmers, leveraging India's varied agroclimatic zones and consumer preferences. Such systems not only enhance income and reduce production risks but also support rural employment, women's empowerment, and nutritional security. Moreover, rearing diverse poultry species under free-range or semi-intensive systems utilizes available natural resources efficiently, lowering feed and infrastructure costs while ensuring environmental and economic sustainability (Aruna and Anand, 2023).

**Benefits of poultry diversification**

***Nutritional Security***

Protein malnutrition remains a persistent issue in India, especially in rural and tribal regions. Poultry meat and eggs, being rich in high-quality animal protein with excellent biological value, are among the most accessible and affordable protein sources. Diversified poultry farming enhances nutritional diversity by ensuring the availability of multiple, nutrient-rich products across households. Native chicken breeds such as Kadaknath and Aseel provide leaner meat, higher micronutrient content, and recognized medicinal properties. Quail meat and eggs are rich in iron and essential amino acids, particularly beneficial for women and children (Ansari et al., 2024). Duck eggs contain higher levels of certain micronutrients and are larger than chicken eggs (Naik et al., 2022). Thus, poultry diversification directly contributes to India's nutritional security goals by improving both the quantity and quality of dietary protein (Pathak et al., 2022).

***Rural Livelihood and Women's Empowerment***

For landless workers, women, and small or marginal farmers, diversified poultry—particularly backyard systems with native or low-input technology (LIT) breeds—serves as a reliable source of livelihood. It requires minimal capital, provides steady income, and supports family nutrition. Women-led self-help groups (SHGs) often manage small poultry units, rearing breeds like Vanaraja, Gramapriya, CARI Nirbhik, CARI Shyma, CARI Debendra etc. for both egg and meat production (Adbhai et al., 2019; Banerjee and Ghosh, 2021). Similarly, rural households engaged in small-scale rearing of ducks, geese, quails, or turkeys benefit from additional revenue streams. Such engagement enhances women's economic independence and strengthens rural family incomes. Promoting poultry diversification at the grassroots level therefore advances inclusive rural development and directly benefits vulnerable communities.

***Disease Resilience and Risk Management***

The poultry sector faces frequent threats from avian influenza and other infectious diseases, which spread rapidly in dense, genetically uniform commercial flocks. Diversified poultry production mitigates these risks by including resilient native breeds and alternative species with stronger immunity and disease tolerance. Ducks, quails, turkeys, and guinea fowls are naturally less susceptible to many avian diseases. Moreover, maintaining multiple species buffers farmers against total losses during disease outbreaks, as income from one species can offset losses in another (Bhadauria et al., 2015; Naik

et al., 2022; Aruna and Anand, 2023). Hence, diversification enhances both biological and economic resilience within the poultry sector.

***Regional and Cultural Significance***

India's rich cultural diversity is reflected in its food traditions and poultry consumption patterns. In eastern and southern states such as West Bengal, Assam, and Kerala, ducks are an integral part of local cuisine, while quail and turkey are favoured in Tamil Nadu and parts of Andhra Pradesh and Kerala. Indigenous chicken meat is highly valued in rural and tribal diets for its unique flavour and traditional appeal. Specialty items, such as pickled quail eggs, also cater to niche markets. By supporting region-specific species and culinary preferences, poultry diversification not only preserves cultural heritage but also aligns production with consumer demand—an area where conventional broilers and layers alone cannot fully meet India's diverse market needs (Naik et al., 2022; Ansari et al., 2024; Karadağ, 2025).

***Potential for Exports***

Although India is one of the world's largest producers of chicken, its contribution to global poultry exports remains relatively limited. However, strong export opportunities exist. Gulf and Middle Eastern markets show consistent demand for halal-certified poultry, along with processed chicken and egg-based products. Likewise, West and East African countries are emerging destinations for protein-rich processed meats and egg products, while South and Southeast Asian nations are increasingly importing chilled and frozen poultry, as well as value-added products. The demand is particularly high for processed and convenience-oriented chicken items such as IQF (individually quick frozen) pieces, marinated ready-to-cook or ready-to-eat products, pre-cooked heat-treated items, chicken sausages, and nuggets. These products not only meet evolving consumer preferences but also minimize cold-chain spoilage risks while supporting higher value realization. Similarly, there is significant export potential for egg-based products including liquid eggs, egg powder, and yolk/albumen concentrates, which are widely used in the bakery, confectionery, and food-processing industries.

***Sustainability and Climate Resilience***

Climate change poses serious challenges for agriculture and livestock through rising temperatures, erratic rainfall, and increased disease stress. Diversification in poultry species and use of indigenous breeds can strengthen resilience because these birds are often better adapted to local climatic stresses, need fewer inputs, and perform more reliably under variable conditions. For instance:

- Indigenous chicken breeds such as Aseel and Kadaknath are known for heat tolerance, disease resistance, and lower input needs, making them suitable for backyard or low-input systems.
- Ducks, especially indigenous varieties, perform well in wetland and coastal regions; they thrive under semi-intensive or free-range systems, forage naturally, and are well adapted to humid and flooded conditions. Crossbreeding experiments (with breeds like White Pekin, Khaki Campbell) show that while exotic or crossbred ducks may give higher yields, indigenous ducks are more climate-resilient and require fewer resources.
- Hardy small species such as Japanese quail are able to withstand disease pressures and climatic extremes, require less feed and space, mature faster, and thus can provide quicker returns, especially for small or marginal farmers.

- Guinea fowl and turkeys, though slower growing (in the case of turkeys), have the potential to be reared in free-range or organic systems. These species contribute to biodiversity in poultry farming and reduce pressure on more resource-intensive commercial chicken lines. Such diversified farming systems are generally more climate-smart and sustainable.

**Potential of Diversified species**

***Duck:***

Ducks (*Anas platyrynchos*) rank second only to chickens among domesticated fowl in terms of meat and egg production. In addition, they are valued for their feathers and ornamental appeal. India's duck population stands at about 3.35 crore, accounting for 3.93% of the country's total poultry population. Indigenous (Desi) ducks constitute the majority (88%) compared to improved varieties (20$^{th}$ Livestock Census, 2019). Ducks serve as a dependable source of livelihood for small and marginal farmers due to several favourable traits, including strong disease resistance, a prolonged laying cycle, ease of training, large egg size, early morning egg-laying habit, and natural foraging ability. Their adaptability makes them particularly suitable for regions with coastal lines, wetlands, or marshy lands where other livestock species or chickens are difficult to rear. According to demographic data, duck farming is most prevalent in states with abundant water resources such as Kerala, West Bengal, Odisha, and the northeastern region (Aruna and Anand, 2023; Padhi and Giri, 2024). As per BAHS (2024), Assam has the highest number of Desi ducks, followed by West Bengal and Jharkhand, while West Bengal leads in improved duck populations, followed by Kerala and Manipur.

Duck meat and eggs often fetch premium prices due to their perceived therapeutic benefits and distinctive culinary appeal. Moreover, integrating ducks with paddy fields and fish farms can enhance overall farm productivity and profitability while reducing feeding costs. In India, duck rearing remains largely seasonal, migratory, and free-ranging, closely tied to farmers' socioeconomic status and local ecological resources. Notable examples include the backwaters of Kerala and the coastal belts of West Bengal and Odisha (Rajput et al., 2014; Padhi and Giri, 2024). Production performance varies widely among duck types. Under comparable rearing conditions, improved ducks produce between 160.25 and 223.13 eggs annually, while Desi ducks yield around 109.6 eggs in backyard systems and 242.5 eggs in commercial setups (BAHS, 2024). This variation underscores the need to enhance the productivity of native ducks through structured breeding and selection programs. According to FAO (2019), India produced 43,941 tonnes of duck meat, with an average carcass weight of 1,069 g and a per capita availability of 89.13 g per year—figures significantly lower than global standards, primarily due to the absence of systematic breeding efforts for meat-type ducks.

Over the years, Indian farmers have reared both native and exotic duck varieties in backyard systems. Prominent exotic breeds include Khaki Campbell, and White Pekin and Indian Runner. The National Bureau of Animal Genetic Resources (NBAGR), Karnal, has officially recognized four native breeds—Pati (Assam), Maithili (Bihar), Andamani (Andaman & Nicobar Islands), and Tripureshwari (Tripura) (ICAR Report, 2024). Other locally important but unregistered types include Kuttanad, Kuzi, Chara, Chemballi, Deo-Hanh, Raj-Hanh, Kudu ducks of Mayurbhanj and Nageswari. Although these indigenous varieties have lower production potential, their resilience to harsh climates, disease resistance, and adaptability to low-input systems highlight their genetic importance. Crossbreeding

programs—particularly between native or non-descriptive ducks and exotic breeds like Khaki Campbell or White Pekin—have been implemented to enhance productivity and reproductive performance (Aruna and Anand, 2024; Padhi and Giri, 2024).

***Turkey:***

Turkey (*Meleagris gallopavo*) farming in India is still at a nascent stage, representing only about 0.05% of the total poultry population—approximately 4.48 lakh birds (20th Livestock Census, 2019). However, its popularity is gradually increasing, especially in the Northeastern and Southern states. Assam currently holds the largest turkey population, followed by Uttar Pradesh and West Bengal. Major turkey strains in India are Beltsville Small White (BSW), Broad Breasted White (BBW). Broad Breasted Bronze (BBB) and Black turkey procured long back from USA. However, they have been acclimatized to our conditions and weight about 5-7 kg with a FCR of 2.5-3.0 at market age of 20-24 weeks. They attain sexual maturity at 30-32 weeks of age and can lay about 90-100 eggs in one biological year. Natural mating has been an issue with turkey thus hatchability on fertile egg set basis may ranges from 75-80%. Of course, the Artificial insemination has been tried but with limited success as semen collection is an issue due to thick and sticky nature of the semen.

Institutions such as the Central Poultry Development Organization (Southern Region), Hessarghatta; ICAR-Central Avian Research Institute (CARI), Izzatnagar (CARI-VIRAT); and TANUVAS (Nandanam-II) have made notable efforts to promote backyard turkey farming as a low-input enterprise (Ilavarasan et al., 2020; Champati et al., 2024). These initiatives aim to strengthen rural livelihoods and promote women's empowerment by integrating turkey production into small-scale poultry systems (Lonkar et al., 2017). Turkey farming in India holds considerable potential due to the bird's adaptability to semi-intensive and free-range systems. Their natural scavenging and foraging abilities make them well-suited to diverse agro-climatic regions. As several studies suggest (Bhadauria et al., 2015; Prabakaran et al., 2020; Aruna and Anand, 2023), promoting turkey rearing can enhance nutritional security and provide a sustainable source of income for rural households.

***Japanese Quail:***

The Japanese quail (*Coturnix coturnix japonica*), a domesticated descendant of the wild migratory quail, has become an increasingly important species in global poultry production. Globally, around 1.4 billion broiler quail are reared each year for meat and egg production, with the demand for quail meat increasing by 5–10% annually. Over 80% of the world's quail production occurs in tropical and subtropical countries, notably China, Indonesia, India, Japan, Brazil, and Mexico (Katerynych and Pan'kova, 2020; Mnisi et al., 2025). In India, the Central Avian Research Institute (CARI), Izatnagar, pioneered quail research and production after importing Japanese quail germplasm from Japan and Davis, California, in 1974. Since then, CARI has developed several improved strains—such as CARI-Uttam, Pearl, and Suneheri-optimized for both meat and egg production. Similarly, TANUVAS introduced Japanese quail germplasm in 1983 and developed its own Nandanam varieties (Aruna and Anand, 2023).

Commonly referred to as Bater in India, quail farming has gained attention as a profitable and sustainable enterprise due to its rapid growth rate, prolific egg production, and low management requirements. It offers considerable potential for income generation and rural employment while being

an enjoyable and rewarding activity (Prabakaran et al., 2020; Ansari et al., 2024). Japanese quails possess several advantageous traits, including faster growth, early sexual maturity (5–6 weeks), high egg yield (approximately 300 eggs per year), short generation interval (3–4 generations annually), and low feed intake (20–25 g per bird per day). They are also less susceptible to common poultry diseases (Jatoi et al., 2013). Their small body size allows for high stocking density—six to seven broiler quails per square foot—and their incubation period is only 17–18 days. They are one of the best experimental animals for biological research. At five weeks of age, a broiler quail reaches around 210 g in weight and yields a carcass with 74–76% dressing percentage, surpassing that of broiler chickens (Gecgel, 2015). Due to low feed efficiency (FCR 2.5-3.0), the cost of production is very high in quail, thus mostly popular in only urban markets. However, quail eggs are gaining recognition as a nutritious and affordable protein source, particularly in developing countries. They are rich in high-quality protein, iron, phosphorus, riboflavin, selenium, folate, vitamin B12, and pantothenic acid. Likewise, quail meat is appreciated for its tenderness, flavor, and nutrient density (Kumari and Mankhair, 2024). Given its favourable production traits, lower capital requirement, and high profitability comparable to chicken and duck farming, quail production presents a viable livelihood option for smallholders and rural entrepreneurs. Furthermore, quails' resistance to diseases and minimal vaccination needs make them ideal for backyard or semi-commercial poultry systems. Promoting quail farming at a larger commercial scale can contribute significantly to nutritional security, income diversification, and rural development in India.

***Guinea fowl:***

The domestic guinea fowl (*Numida meleagris*), native to South Africa, has gained global popularity for its uniquely flavoured meat and eggs, often compared to wild game birds. With an estimated population exceeding 50 million, Across Africa, the species is typically managed under low-input, free-range conditions. In several European and North American countries, backyard and small-scale farmers also rear guinea fowl for their distinctive gamey meat and for natural pest control (Houndonougbo et al., 2017).

Guinea fowl meat is lean, rich in essential fatty acids, and offers a higher carcass yield than chicken. Their eggs possess thick shells, making them less prone to breakage. In India, guinea fowl rearing is still limited, mainly confined to backyard systems serving local markets or household consumption. The three predominant color varieties are pearl, white, and lavender. Through selective breeding of native stock, ICAR–Central Avian Research Institute (CARI) developed improved strains collectively known as "Guncari" (Kadambari, Swetambari, and Chitambari). These varieties exhibit enhanced disease resistance, better growth performance, and stable plumage characteristics. While Guncari types are seasonal layers, the Tamil Nadu Veterinary and Animal Sciences University (TANUVAS) has developed the Nandanam Guinea Fowl-1, which lays eggs throughout the year (Prabakaran et al., 2020; Aruna and Anand, 2023).

Guinea fowls are hardy and efficient foragers, capable of consuming unconventional feed resources unsuitable for chickens. They also show notable resilience to mycotoxins. Their eggs, each containing about 13.7 g of protein, are nutrient-dense and rich in iron, zinc, selenium, and essential vitamins such as A, B12, and D. Additionally, guinea fowl eggs contain omega-3 fatty acids that promote cardiovascular health and reduce inflammation. The meat, characterized by its low cholesterol content

and high vitamin concentration, is increasingly recognized as a healthy dietary option (Rayan et al., 2022; Rambabu, 2025).

In India, guinea fowl typically reach market weight between 1.2-1.4kg at 16–18 weeks of age, though 12 weeks is considered the ideal slaughter age. Females begin laying at around 16 weeks, mostly seasonal (March – September) and produce approximately 100 eggs per year. Due to their adaptability to both hot and cold climates, guinea fowls are particularly suitable for backyard rearing in southern and northeastern hilly regions. With their resilience, nutritional value, and low management needs, guinea fowls hold significant potential for diversification and income generation within India's rural poultry sector. The research conducted at CARI, Izatnagar (with nutritional and light management) has primed the guinea fowl to produce egg during non-seasonal periods also. There is also need for developing more feed efficient guinea fowl for their commercial exploration.

***Geese***

Traditionally, geese are reared for meat, eggs, and down feathers. Globally, domestic geese are primarily derived from two species: the European goose (*Anser anser*), originating from the Greylag goose, and the Asian goose (*Anser cygnoides*), descended from the wild swan goose. Asia accounts for a significant majority of global goose production (96%), with China alone contributing over 99% of the regional output (Biswas et al., 2015). In India, the Kashmir Anz, a breed native to the Kashmir Valley and is valued for its tender meat. Across northeastern India, farmers primarily rear non-descriptive local geese under free-range or scavenging systems with minimal inputs, obtaining valuable products such as meat and down feathers. Geese are particularly suited for sustainable agriculture due to their ability to efficiently digest high-fiber diets and survive on green pastures or post-harvest residues. Native non-descriptive goose types exhibit high carcass yield, around 78% with skin, compared to 68% in Kashmir Anz and some Australian varieties. They also demonstrate rapid juvenile growth and strong disease resistance (Hamadani et al., 2020).

Although goose farming remains an underexploited sector in India, the country's abundant water bodies and paddy fields offer significant potential for expansion. Minimal infrastructure and feed investment are required, making it possible to rear large flocks under extensive systems, thereby generating additional income for farmers. With their long lifespan, resilience, and adaptability, geese can contribute to rural livelihoods, specialized poultry markets, and the development of sustainable and diversified poultry production systems.

***Ostrich and Emu:***

Ostriches (*Struthio camelus*) and Emus (*Dromaius novaehollandiae*) are flightless birds belonging to the ratite family, valued globally for their meat, leather, and feathers. Ostrich products are in high demand due to consumer interest in luxury goods, exotic meats, and sustainable livestock alternatives (Mnisi et al., 2025). Ostrich meat is particularly sought after for its low fat and cholesterol content, making it appealing to health-conscious consumers and expanding the species' market potential. While the global market remains niche, countries such as South Africa, the United States, Europe, and parts of Asia are increasing ostrich production to meet the growing demand for high-quality, eco-friendly meat (Needham and Hoffman, 2022). In addition, leather and feathers are highly profitable, particularly in luxury and industrial segments.

In India, ostrich farming is a relatively recent venture. The first pilot farm was established by TANUVAS in 2000 (Selvan et al., 2012). The primary focus is on red meat and durable leather. Ostrich meat is rich in polyunsaturated fatty acids, high in protein, and low in fat. Under Indian conditions, feed conversion ratios (FCR) are optimal between 1.6 and 1.7 months of age, increasing as birds approach seven to eight months (Selvan et al., 2012). Growth of the sector is limited by factors such as inadequate marketing channels for byproducts and the high costs associated with maintaining birds until they reach marketable size.

Emu farming in India is also emerging, with notable production in Andhra Pradesh, Tamil Nadu, Maharashtra, and Kerala. Adult emus weigh between 40 and 50 kg and stand 5–6 feet tall. The species is valued for its low-fat red meat with a distinct gamey flavor, as well as its feathers, hide, and oil (Kiran et al., 2009). Marketable emu oil, extracted from fat at 15–18 months of age, yields 5–6 liters per bird and is prized in cosmetics (Warale et al., 2014). Emu eggs are large, weighing 700–800 g, with an emerald green shell, and hatch in 48–50 days. Adult hides can produce eight square feet of premium leather for clothing, belts, and boots, while toenails, eggshells, and feathers are also used in decorative products.

Challenges in India include high FCR, delayed harvesting of hides and oil until birds reach adulthood, and limited marketing infrastructure for byproducts. Developing additional processing facilities and expanding market channels are crucial for realizing the full economic potential of ostrich and emu farming (Aruna and Anand, 2023). Despite these constraints, ratite production presents a promising opportunity for diversification, sustainable meat production, and luxury product markets in India.

**Major constraints in diversified poultry farming**

The diversified poultry sector in India faces several challenges hindering its widespread adoption and growth.

***Key Challenges***

- Localized product demand: Consumer preferences for poultry products often vary regionally, leading to inconsistent demand across different areas.
- Unorganized supply chains: The poultry supply chain remains fragmented, with numerous small and medium-sized farms serving local markets. This lack of integration complicates logistics and distribution, leading to inefficiencies and increased costs.
- Low fertility and hatchability: Certain alternative poultry species exhibit lower reproductive performance, including reduced fertility and hatchability rates, which can limit production scalability.
- Limited capacity building facilities: There is a scarcity of specialized training centers and programs to equip farmers with the necessary skills and knowledge for managing diverse poultry species effectively.
- Lack of specialized veterinary and technical support: Veterinary services and technical assistance tailored to the specific needs of non-chicken poultry species are insufficient, affecting disease management and overall productivity.

- Productivity gaps: Alternative poultry species often have smaller populations, slower growth rates, and lower egg production compared to traditional poultry, leading to reduced economic viability.
- Policy issues and insufficient subsidies: Government policies tend to favor traditional poultry farming, with minimal support or subsidies for alternative poultry species, hindering their development and adoption.

Addressing these challenges requires coordinated efforts from government agencies, agricultural institutions, and industry stakeholders to create a more supportive environment for diversified poultry farming in India.

**Prospects of Diversified species**

To enhance the competitiveness of India's diversified poultry sector against the commercial chicken industry, a comprehensive approach is essential. This strategy should encompass farmer capacity building, product commercialization, and the establishment of robust support systems.

***1. Farmer capacity building***

Empowering farmers with the necessary skills and knowledge is crucial. Institutions like ICAR-CARI and ICAR-DPR have initiated training programs focusing on scientific poultry management, disease prevention, and sustainable farming practices. For instance, ICAR-CARI organized a training session on 'Scientific Management of Poultry' in collaboration with ICAR-Krishi Vigyan Kendra in Thrissur, Kerala, aimed at enhancing the capabilities of farmers

***2. Product commercialization and branding***

To promote diversified poultry products, establishing a unified branding system is vital. Adopting a model similar to France's Label Rouge program could be beneficial. Label Rouge is a certification that guarantees poultry products are produced with high standards of animal welfare and environmental sustainability, catering to regional markets. Implementing such a system in India could involve creating regional producer alliances, ensuring quality control, and marketing products under a common label.

***3. Policy support and institutional collaboration***

Government agencies and institutions should collaborate to provide comprehensive support. Programs like RKVY, NLM, SHGs, and NGOs can play a pivotal role in promoting policies, offering subsidies, and facilitating market access. Additionally, institutions such as ICAR-CARI, ICAR-DPR, and state agricultural departments should work together to develop and disseminate improved poultry breeds, like Vanaraja CARI Debendra, CARI Nirbhik and Giriraja, which are well-suited for rural and backyard farming.

**4.** ***Research and development***

Investing in research to develop new poultry breeds with enhanced growth rates, feed efficiency, and adaptability is essential. This includes exploring innovative reproductive technologies, such as artificial insemination, to improve fertility rates. Collaboration between research institutions and farmers can facilitate the development of poultry breeds that meet the specific needs of diverse farming systems.

***5. Market development and value addition***

Expanding market opportunities for diversified poultry products is crucial. This can be achieved by developing value-added products like smoked duck, quail egg pickles, and tandoori quail. Establishing dedicated marketing channels and promoting these products can increase consumer awareness and demand.

**Conclusion**

India's poultry sector is experiencing significant growth, driven by increasing protein demand and evolving consumer preferences. While the commercial broiler and layer industries have stabilized, there is a growing interest in diversified poultry farming, encompassing species such as turkeys, quails, guinea fowls, geese, ostriches, and emus. This diversification offers opportunities for rural development, nutritional security, and income generation. Transforming India's diversified poultry sector requires a multifaceted approach involving capacity building, branding, policy support, research, and market development. By implementing these strategies, the sector can achieve sustainable growth and contribute significantly to rural livelihoods and food security. Through "Vision 2050," central government organizations that oversee the Indian poultry industry, such as the Central Avian Research Institute, Izatnagar and Directorate of Poultry Research, Hyderabad have envisioned a radical transformation of the diverse poultry industry for the purposes of ensuring nutritional security and generating additional revenue as an alternative to the commercial poultry industry. For profitable production, market surveys should be conducted to determine the demand for particular goods and economic feasibility studies should be conducted to confirm that a given species can be produced in the current agroclimatic conditions. Additionally, in order to preserve valuable germplasm, local breeds and variants of diverse poultry species should be characterized. Thus, the industry's creative thinking and environmentally friendly manufacturing techniques will remain essential to guaranteeing future food security.

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LP-14

# Poultry Welfare - Challenges and Practices in Vikasit Bharat

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The poultry sector in our country has grown in leaps and bounds over last few decades. This growth has been in tune with the requirement of the country with respect to the nutritional security of its growing population. The growth has also occurred in accordance with the changing demands of the people in our country. Initially, the demands pertained to sufficiency with respect to quantity of the poultry products which gradually changed to the sufficiency with respect to quality and many other aspects attached to both, the production and the consumption patterns have been noticed. The impact of the developed western world on food habits and systems of production of food has also impacted the growth and development of the poultry sector. It's not only the food security that has changed to the nutritional security, but the traceability and freedom from unwanted entities in the food has also creeped in the production systems. This has given rise to the societal issues defining the likes and dislikes of the way in which the food is produced, including the animal origin foods like eggs and poultry meat.

Of late the traceability of eggs and meat with respect to the source of the products, hygiene, freedom from unwanted residues and assurance of welfare of birds with no cruelty whatsoever in the production process has become a key factor to decide the consumer preference in our country. This has highlighted the importance of bird welfare in the production systems. Unfortunately, some of the organisations/ public bodies use this welfare issue for false propaganda about the poultry products. They use welfare related issues to discourage the masses and refrain people from consumption of eggs and meat thereby forcing them to stay away from the most nutritious and affordable protein sources available from birds.

It is also true to some extent that the demand for the poultry products increased drastically in view of the growing population of the country and it became necessary to produce animal agricultural products in more quantity. More emphasis was also led on increasing the productivity and all this started bringing in the stress on the production system and the issue of welfare started coming into limelight. Limited production by masses that was being practised earlier never created welfare issues. However, production in masses in recent times increased the welfare issues and in some parts of our country it is true. Importance to the bulk production, efficient production and thereby improved productivity has certainly brought stress on the birds compromising their welfare to certain extent. As many a times, it is believed that welfare and productivity are inverse to each other, if one of them is over rated and another gets undermined. Therefore, a balance between both along with economic consideration and ethics should be maintained in all production systems to ensure welfare of birds. Thus, it is necessary to balance welfare and production in animal agriculture. Here one must remember that the welfare of the birds is inseparably linked with the birds' health and productivity. Ensuring birds' health and welfare ensures productivity. These measures will improve the physiology and survival of birds improving productivity. Hence, welfare, health, ethics and productivity are the four pillars of acceptable animal agriculture in Vikasit Bharat.

In year 1993, United Kingdom formed bird welfare council and it published new five freedoms for the birds.

- Hunger
- Discomfort
- Pain and suffering from disease
- Freedom from fear and distress
- Freedom to express the normal behavior.

As long as these five freedoms are granted to the birds, the birds are said to have been reared in the production system where in the welfare is ensured. Moreover, it may also be thought that when the birds can survive, sustain and produce reasonably well as per the expectations, their welfare is ensured. In our country the birds perform as per the global standards hence the productions systems in terms of housing management, feeding, health care etc. are all up to the mark. However, there are concerns over some of the issues in the production systems which could be listed as below.

- Cage rearing
- Debeaking
- Catching and Transportation
- Handling (Holding birds upside down)
- Forced molting
- Dubbing and Detoeing
- Destroying males at young age
- Artificial insemination Vs Natural mating
- Overcrowding / floor space provided per bird

In addition, the other societal issues related to welfare are

- Intensive housing system
- Waste Disposal – Droppings and Dead bird disposal
- Pollution
- Smell / Odor
- Fly problem

The way forward for Vikasit Bharat is to gradually find out solutions for these issues in future by modulating production systems and adopting newer technologies. Some of the possible solutions could be use of alternative poultry production systems like free range, enriched cages, aviaries etc. have been suggested to ensure welfare. However, all these would involve increase in the investment and cost of production of eggs and meat. In a country like India, poultry eggs and poultry meat are the best still the most reasonable, rather cheap, sources of protein for human nutrition. Affordability of these products by common people has been one of the encouraging factors in the growth and development of poultry sector as such.

Therefore, in my opinion the present rearing systems followed in our country are quite balanced. These systems are giving due emphasis on welfare and ethics with due consideration to the economics. The cost of production and the selling price of eggs and poultry meat are well within the reach of common people and are also ensuring moderate profits for the producers. Any intervention in the present-day production systems would bring alarming changes in the scenario of the poultry sector, making the egg and meat unaffordable. Our country cannot afford it. The basic purpose and the silent revolution brought about by these products of sufficing the protein hunger of the growing Indian population would get defeated if any further and extra emphasis is laid on welfare and ethics. I feel, as mentioned earlier the ethics and welfare are being well secured.

LP-15

# Waste to Wealth: Scope of Poultry Waste as a Source of Green Energy

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## Introduction

The poultry industry is one of the fastest-growing agricultural sectors globally, contributing significantly to food security and rural employment. However, it also generates large volumes of waste-including **manure, feathers,** dead birds, hatchery wastes, abattoir residues**, and litter**-that, if unmanaged, can lead to serious environmental issues such as groundwater pollution, air contamination, and greenhouse gas emissions. The "waste to wealth" emphasises converting what is otherwise a disposal problem (and environmental liability) into a value-stream (energy + by-products).

Poultry wastes contain organic matter, nutrients, sometimes moisture, and thus potential energy/carbon if processed properly. Converting poultry waste into energy presents a **sustainable solution** that not only mitigates environmental problems but also generates **renewable energy** and value-added by-products. This aligns with global goals for **green energy, waste minimization, and circular economy practices**.

- "Green energy" refers to converting poultry waste into usable energy forms such as:

- Biogas or biomethane via anaerobic digestion
- Thermal energy / electricity via gasification, pyrolysis or combustion
- Bio-char or solid fuels from thermochemical routes

## Scope / Potential

India is the second largest egg producer and third largest broiler chicken producer in the world with production estimates of 65,000 million (2.8 million tonnes) eggs and 3.2 million tonnes of broiler meat per year (BAHS, 2016). Nearly 20 million farmers are employed in poultry industry with around 614 hatcheries operating across India. While agricultural production has been rising at the rate around 2 per cent per annum over the past three decades, poultry production has been rising at the rate of 8-10 per cent. South India accounts for the majority of total poultry production and consumption in the country. Andhra Pradesh, Karnataka, Kerala, Tamil Nadu and Maharashtra states in the south and Haryana, Punjab in the north are key regions in this aspect. Tamil Nadu stands second largest poultry meat producing state (4.12 lakh tonnes) next to Maharashtra (4.5 lakh tonnes) (BAHS, 2016).

## Types of Poultry wastes and its Uses

1. **Poultry Manure (Droppings):** The most abundant waste from poultry farms, composed of feces and urine.
2. **Litter Waste:** A mixture of poultry droppings, spilled feed, feathers, and bedding materials (such as wood shavings, sawdust, rice husk, or straw).
3. **Hatchery Waste:** Produced in hatcheries where eggs are incubated and chicks are hatched. And it

**includes**Infertile eggs, Dead embryos, Broken eggshells, Unhatched eggs, Fluff and paper waste

4. **Mortality (Dead Birds):** Dead or culled birds due to disease, deformities, or age.
5. **Feathers:** Generated during processing or molting.
6. **Wastewater:** Water contaminated with manure, blood, feathers, feed residues, and cleaning agents from poultry houses and processing units.
7. **Processing Plant Waste (Slaughter house Waste):** Produced during poultry meat processing. Which **includes** Blood, Offal (internal organs, intestines), Bones, Fat, Feathers and wash water.

**Energy Conversion Technologies**

1. **Anaerobic Digestion (AD)**
   - Poultry manure is digested by microorganisms in the absence of oxygen.
   - Produces **biogas** (methane + $CO_2$) and **digestate** (a nutrient-rich fertilizer).
   - Example output: 1 ton of poultry litter can yield ~50–80 $m^3$ of biogas.
   - Biogas can be used for electricity generation, heating, or upgraded to biomethane for fuel.
2. **Thermochemical Conversion**
   - **Pyrolysis:** Converts dried litter or feathers into **bio-oil, syngas, and biochar**.
   - **Gasification:** Produces a combustible gas mixture (CO, $H_2$, $CH_4$).
   - **Combustion:** Direct burning for heat and power generation.
   - Advantage: Handles high solid waste and kills pathogens.
3. **Biodiesel Production**
   - Poultry fat and offal can be processed via **transesterification** to produce **biodiesel**.
   - This renewable fuel can replace fossil diesel in engines or generators.

**Environmental and Economic Benefits**

1. **Environmental Benefits**
   - Reduces methane and ammonia emissions from unmanaged waste.
   - Prevents groundwater and soil contamination.
   - Produces renewable energy, offsetting fossil fuel use.
   - Biochar and digestate enhance soil fertility.
2. **Economic Benefits**
   - Cuts energy costs for poultry farms.
   - Generates additional income through sale of biogas, biodiesel, or organic fertilizer.
   - Supports rural development and energy self-sufficiency.
   - Creates green jobs in waste management and renewable energy sectors.

**Challenges**

- High moisture and nitrogen content in poultry litter complicate processing.
- Collection and segregation of waste require logistics and investment.
- Small-scale poultry farms may lack technology access.
- Need for policy support, subsidies, and technical training.

**Future Prospects**

- **Integrated biorefineries** combining anaerobic digestion, composting, and biofuel production.
- **Microbial and enzymatic pretreatments** to enhance biogas yield.
- Use of **nanotechnology** and **AI-based systems** for waste monitoring and process optimization.
- Government incentives and public-private partnerships to scale up rural biogas plants.

**Summary:**

- Poultry waste is a significant feedstock for green energy due to its organic content and large volumes.
- Technologies such as anaerobic digestion, gasification/pyrolysis, microalgae integration offer multiple pathways to convert waste into energy and by-products.
- The "waste-to-wealth" concept holds strong promise: environmental benefits, energy generation and resource recovery.
- However, successful deployment depends on proper technology selection, economic viability, logistics, scale, policy support and operational stability.
- For a region like Tamil Nadu/India, there's strong relevance: Aligning poultry industry waste with renewable energy strategies could yield both sustainability and economic benefits.

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LP-16

# Poultry science education in India: current status and future directions

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## Introduction

It is increasingly recognized that Poultry Science must be treated as an independent academic discipline, requiring greater emphasis on imparting comprehensive and specialized knowledge across its various dimensions. The evolving landscape of the poultry sector, driven by advances in technology, genetics, nutrition, and global trade, demands a thorough revision and modernization of the Poultry Science syllabus at both undergraduate and postgraduate levels to align education with industry requirements. To effectively address the growing needs of rural and commercial poultry development, educational institutions must focus on expanding their efforts to produce trained manpower at all levels from field technicians to research scientists equipped with the technical competence necessary for sustaining and advancing the poultry industry. Therefore, there remains a continual need to infuse dynamism into the discourse on the status and direction of poultry science education—ensuring that academic institutions evolve in line with the ever-changing global demands and opportunities in Poultry Science.

## Importance of Poultry Science Education in India

Poultry Science education plays a crucial role in supporting and sustaining India's rapidly expanding poultry industry, which is among the largest in the world. It provides the scientific foundation required for efficient, profitable, and sustainable poultry production.

1. **Human Resource Development:** It equips students, veterinarians, and farmers with technical knowledge and practical skills in breeding, nutrition, management, and disease control, ensuring a continuous supply of trained professionals for the poultry sector.
2. **Improved Productivity and Efficiency:** Scientific education helps optimize production parameters such as feed conversion ratio, growth rate, and egg yield, leading to higher profitability and better resource utilization.
3. **Disease Prevention and Health Management:** Education in poultry science strengthens understanding of biosecurity, vaccination, and diagnostic techniques, reducing losses from infectious diseases and improving flock health.
4. **Research and Innovation:** Poultry science fosters research in genetics, nutrition, physiology, and biotechnology, promoting innovations like improved breeds, functional feeds, and climate-resilient housing systems.
5. **Entrepreneurship and Employment:** Poultry education encourages entrepreneurship, enabling youth and rural farmers to establish poultry farms, hatcheries, or feed units, thus generating employment and income opportunities.
6. **Food and Nutritional Security:** By improving poultry production and quality, it contributes

significantly to national food security and provides affordable, high-quality protein sources like eggs and chicken meat.

7. **Sustainability and Welfare:** Knowledge of environment-friendly farming, waste management, and animal welfare ensures that production is sustainable and ethically responsible.

**Peep into graduation -VCI, New Delhi**

At present, as per Veterinary Council of India course curriculum 2016, the poultry science curriculum covered as a part of Livestock Production and Management (4+2); subject which is taught at first year level under the sub title of Poultry Production Management and Diversified Poultry Production, and Hatchery Management (unit 6 and 7). Subsequently the undergraduate students get little exposure of Poultry Species in the third year under the Livestock Farm Practices Course (0+2=2). The Poultry science merely contribute < 25 % syllabus of Livestock production and Management. At the end of degree program during internship students get exposed themselves for poultry related activity for almost one month. After continue persuasion from Indian Poultry Science Association and Industry Personals, it is expected that separate Poultry Science (PSC) subject will be implemented (Draft MSVE 2023, under consideration). As per the new proposed draft the Poultry Science will be taught in second year IV semester 1. PSC-221: - Poultry Science I: Management (2+1) 2.PSC-222: - Poultry Science II: Health Care (1+1). Apart from the core subject of PSC, the undergraduate students will get exposure of poultry species under the course title Livestock Farm practices (LFC) at third year and during their internship program.

**Glimpse at post-graduation level-ICAR, New Delhi**

In 2022, Common Academic Regulations for PG and Ph.D. Programmes was sketched by Broad Subject Matter Area (BSMA) committee of well-known academician. While developing the syllabi, various provisions of National Education Policy-2020 have also been considered and complied to provide quality higher education and develop creative individuals. BSMA committee categorized the Veterinary Subjects into four parts i.e. 1. Basic Veterinary Sciences 2. Veterinary Clinical Subjects, 3. Veterinary Para-clinical Subjects 4. Animal Production Sciences (Poultry Science)

The BSMA committee of Animal Production Science emphasised to create a separate Department of poultry Science in each veterinary College at Post graduate level. In new syllabus of Poultry Science at PG level gave emphasis on new scientific techniques, value-addition, post-harvest management, methods of organic poultry production, formulation of bankable projects with minimal expenditure in poultry production and also on utilizing the by-products from poultry processing and waste Overall the course has been designed in such a way so as to focus to enhance skills for tackling emerging problems in this sector, increase employment and also focus has been given to cope up the post-covid-19 challenges.

**Internship During Masters programme:** There is hardly any opportunity/ provision under this system to enhance the entrepreneurship skills of those students who could start their own enterprise or have adequate skills to join the industry. Therefore, in order to overcome this gap, an optional internship/ in-plant training Internship for Development of Entrepreneurship in Agriculture (IDEA) in lieu of thesis/ research work is recommended which will give the students an opportunity to have a real-time hands-on experience in the industry.

**Master Degree Program in Poultry Science (MVSc):** Several government-recognized agricultural and veterinary universities in India offer an **MVSc (Master of Veterinary Science) in Poultry Science.** These programs are affiliated with the Indian Council of Agricultural Research (ICAR), ensuring standardized education and accreditation.

- Indian Veterinary Research Institute (IVRI), Bareilly
- U.P Pandit Deendayal Upadhyay (DUVASU), Mathura
- Maharashtra Animal and Fishery Sciences University (MAFSU), Nagpur
- Tamil Nadu Veterinary and Animal Sciences University (TANUVAS), Chennai
- P. V. Narsimha Rao Telangana Veterinary University, Hyderabad
- Nanaji Deshmukh Veterinary Science University, Jabalpur
- Kerala Veterinary and Animal Sciences University (KVASU), Kerela
- Govind Ballabh Pant University of Agriculture and Technology (GBPUAT), Pantnagar
- Karnataka Veterinary Animal and Fisheries Sciences University (KVAFSU), Bidar:
- Assam Veterinary and Fishery University, Khanapara, Assam
- Odisha University of Agriculture & Technology (OUAT), Bhubaneswar:
- Dau Shri Vasudev Chandrakar Kamdhenu Vishwavidyalaya, Durg (CG)
- Kamdhenu University, Gandhinagar (Guj)

**PhD Program ICAR, New Delhi**

The respective BSMA Committees have examined the existing PhD syllabus and analysed carefully in terms of content, relevance and pattern and then synthesized the new syllabus. Many existing courses were upgraded with addition and deletion as per the need of the present situation. The revised curricula of PhD have been designed with a view to improve the existing syllabus and to make it more contextual and pertinent to cater the needs of students in terms of global competitiveness and employability. A special provision to enrol for online courses and take the advantage of e-resources through e-learning and teaching assistantship for Ph.D. scholars.

**Special degree programs in poultry science**

**Bachelor of Science (B.Sc.) in Poultry Science:**The Kerala Veterinary and Animal Sciences University (KVASU, Kerala) offers a full-time, three-year degree in **B.Sc. Poultry Production and Business Management.** A 3-year program that often requires a 10+2 in science with a minimum of 55% marks. A Bachelor of Science (B.Sc.) in Poultry Science is an undergraduate degree program that focuses on the scientific and practical aspects of raising poultry for meat and egg production. Graduates are prepared for various roles in the poultry industry, such as in farms, hatcheries, and processing plants, or can pursue opportunities in poultry-related research and education

**B. Tech in Poultry Production Technology:** Tamil Nadu Veterinary and Animal Sciences University (TANUVAS, Tamil Nadu) offers a B. Tech in Poultry Technology, a four-year undergraduate program that covers poultry science, management, and engineering. Admission is based on 12th-standard marks in Mathematics, Physics, and Chemistry, and the program aims to provide students with both theoretical

knowledge and practical skills for the poultry industry. B.Tech in Poultry Production Technology is a four-year undergraduate program that applies engineering and technology principles to the poultry industry, focusing on modern poultry farming. Graduates find careers as farm managers, breeders, production supervisors, or in poultry-related agribusiness and research

**Suguna Institute of Poultry Management (SIPM):** An educational institution founded by the Suguna Group to train students in all aspects of poultry management. The institute offers B.Sc. & M.Sc Poultry Science degree and diploma in Commercial Broiler Production Management, and Diploma in Broiler Breeder Production courses approved by Alagappa University and provides a combination of theoretical and hands-on training to prepare students for careers in the poultry industry. Eligibility typically requires a plus two or equivalent qualification with an average of 50% marks and applicants must be under 23 years of age

**Diploma & certificate programs in poultry science**

- **PG Diploma in Poultry Husbandry:** The Indian Veterinary Research Institute, Bareilly is offering a one-year PG diploma in Poultry Husbandry. Essential qualification for the PG diploma is BVSc & AH. A postgraduate (PG) diploma in poultry husbandry or a related field provides comprehensive knowledge in poultry production and health. The course curriculum including theory and practical is conducted at Central Avian Research institute, Bareilly.

- Dr. B.V. Rao Institute of Poultry Management and Technology (DRBIPMT): DRBIPMT**,** located near Pune, which is dedicated to poultry science and management. The institute was founded by the "father of the Indian poultry industry," Dr. B.V. Rao, and is now part of the large Venkateshwara Hatcheries Pvt. Ltd. (Venky's) group, a leading integrated poultry group in Asia. The primary objective of the Institute is to aid the progress and development of the Poultry Industry by providing it with successful entrepreneurs and skilled manpower through programmed and scientific training

- **Certificate in Poultry Farming (CPF):** IGNOU (Indira Gandhi National Open University) offers a Certificate in Poultry Farming (CPF) program through its School of Agriculture for those interested in poultry science, with a focus on practical and commercial aspects of the industry. This 6-month program is designed for farmers, rural youth, and entrepreneurs to develop skills in areas like breeding, housing, feeding, and healthcare. It is a distance learning course that includes theoretical knowledge, practical exercises, and assignments, with a minimum eligibility of class 12.

**Short training courses in poultry science**

**Centre of Excellence for Animal Husbandry (CEAH), Bengaluru:** This Organisation is modelled on three knowledge pillars (3is)-Latest Information, Inspiration and Innovation for the knowledge aspirants across the country and globe in the Animal Husbandry Sector. The centre works to Develop Capacity Building for Training in Domain Expertise for Animal Husbandry Officers and Entrepreneurs across the Country and the Globe. Centre act as a nodal centre for Capacity Building Commission. CEAH helps in establishing farmer demo units with successful business models for adoption at field.

- **Poultry Research & Training Centre (PRTC) Nagpur Veterinary College, MAFSU, Nagpur:** Poultry Research and Training Centre, Department of Poultry Science, Nagpur Veterinary

College, MAFSU conducts five-day training program for youths, women and poultry farmers. The training program is designed in such way so that new poultry entrepreneurs will get basic information of poultry farming before entering into the poultry business. The training Centre also engaged in conducting training program for Poultry Business representative of industry as well state governing different bodies related to sustainable livelihood for three days.

- **Swayam Platform (SP):** Free online education Swayam platform introduced by Ministry of education and designed to acquaint with the status and perspective of Indian Poultry industry & Advantages of poultry farming and its future scope. The course is delivered through 20 videos lessons in span of about 10 weeks. Every week, learners will have to go through the video lessons. The video lessons are supported by the self-learning material. In addition, a number of web link will be provided to support the study material and to get the updated information. Self-assessment question will be provided after each lesson. Learners have to complete the assignment after going through major sections of study material. The course on introduction to poultry farming is useful to those who are working in the poultry farm or who want to build their career as an entrepreneur as this course provides basics about the poultry farming.

**Future direction for poultry science education**

Future poultry science education in India should focus on integrating technology like AI and data analytics for precision farming, sustainability and biosecurity, and risk and crisis management skills for students. The graduate level syllabus should revise to match emerging trends & Industry needs. The Post-graduation program in Poultry Science subject should start in all the university. The number of seats for Post-graduation in Poultry Science should increase to cater the need of industry with necessary changes in syllabus considering the following points.

- **Recognition and Curriculum Strengthening:** There is a strong need to accord Poultry Science the status of an independent academic discipline in all veterinary and agricultural universities and to re-establish or strengthen dedicated Departments of Poultry Science with full-strength faculty in every veterinary college. The undergraduate and postgraduate curricula must be revised and modernized to include emerging areas such as Precision Poultry Farming (AI, IoT, Robotics), Biotechnology and Genomics in Poultry Breeding, Climate-Smart Poultry Production, Animal Welfare and Ethical Farming Systems, along with Entrepreneurship, Agribusiness, and Value Chain Management. To reflect the increasing importance of the poultry sector within livestock production, the number of course credits in poultry science should also be enhanced. Additionally, postgraduate diploma programs of 6 months to 1-year duration should be introduced wherever they are not currently available. With Tamil Nadu and Kerala veterinary universities already initiating B.Tech programs in Poultry Technology, it is critical to strengthen and regularly update Poultry Science syllabi at both UG and PG levels; otherwise, delayed reforms may lead to the poultry sector drifting away from veterinary science, resulting in the potential loss of academic identity and professional relevance in the veterinary education system.
- **Practical Training and Human Resource Development:** To strengthen practical skills and workforce development in the poultry sector, internship programs should be enhanced with a choice-based system, ensuring that at least one-third of the internship duration is devoted to poultry production and management. Poultry Trade Schools need to be established at the district

level to provide two-year intensive, hands-on training for post–high school students aspiring to build a career in poultry farming. Additionally, setting up Poultry Polytechnics offering three-year diploma or certificate programs after 10+2 will help produce a pool of skilled poultry technicians.

- **Integration with Business and Management Education:** Integrating Poultry Business, Entrepreneurship, and Marketing modules into MBA, PGDBA, and PGDBM programs is essential to develop a pool of professionally trained managers who are well-versed in the economic and operational aspects of the poultry industry. Such specialized training will equip graduates with the necessary skills in value chain management, market analysis, financial planning, and enterprise development, ultimately enhancing managerial competency and strengthening the overall growth and competitiveness of the poultry sector
- **Digitalization and Technological Advancement:** The integration of digital technologies into poultry education and industry operations is essential for future growth and modernization. This includes developing and deploying software tools for feed formulation, disease diagnosis, flock management, record keeping, and automated operations to enhance efficiency and decision-making. Expanding off-campus, online, and distance learning programs will make poultry education more accessible to professionals and entrepreneurs who cannot attend regular courses. Additionally, dedicated e-learning platforms and virtual classrooms will support interactive and flexible training in poultry production and processing. Establishing a national digital index of Poultry Science education and research institutions will further streamline access to academic resources, foster networking, and strengthen collaborative opportunities across the country.
- **Extension, Awareness, and Public Engagement:** Increasing public awareness about the nutritional, economic, and health advantages of poultry products through mass media campaigns, exhibitions, and outreach programs is vital to boost consumption and support informed choices. To strengthen extension services, **Kukkut Vigyan Kendras (KVKs)** should be established nationwide, modeled on Krishi Vigyan Kendras, to facilitate technology transfer, field demonstrations, and farmer training. State Agricultural and Veterinary Universities should also set up regional and district-level poultry demonstration and training units to promote hands-on learning, innovation adoption, and improved farmer–industry collaboration.
- **International Collaboration and Advanced Training:** Establishing an International Centre for Advanced Education and Training in Poultry Science (Tropical Region) is essential to strengthen global academic and research collaboration. This centre would offer specialized diploma, master's, and research programs in tropical poultry science, positioning India as a hub for international students and professionals seeking advanced expertise. By collaborating with global organizations such as the FAO and partnering with leading universities worldwide, the center can enhance training quality, facilitate knowledge exchange, and significantly elevate the international recognition and competitiveness of India's poultry science education and research.
- Focus on Welfare, Ethics & Sustainability: Exposure to our students on welfare, ethics, and sustainability in poultry is reshaping production systems to ensure responsible and humane practices. The emphasis is on providing birds with better living environments, stress-free handling, and enriched housing while minimizing environmental impacts such as waste, emissions, and resource use. Integrating these principles into poultry science education ensures that upcoming

professionals are well-equipped to support global demands for safe, ethical, and environmentally responsible poultry products, ultimately enhancing consumer trust and industry sustainability

- Homeopathy in Poultry Science: Homeopathy in poultry science education is gaining attention as a complementary approach to improve bird health, reduce antibiotic dependence, and support sustainable poultry production. Integrating homeopathy into poultry science curricula can equip future professionals with knowledge of alternative therapeutics, broaden their healthcare strategies.
- Industry–Academia Partnerships: Industry–academia partnerships in poultry play a crucial role in bridging the gap between theoretical education and practical field requirements. These collaborations facilitate joint research, technology transfer, skill development, and real-time problem-solving. Strengthening such partnerships supports the growth of the poultry sector by promoting innovation, sustainability, and a workforce aligned with evolving industry needs.

## Conclusion

In conclusion, Poultry Science education in India is at a pivotal stage of transformation, driven by the rapid expansion of the poultry sector and the growing demand for skilled professionals who can contribute to innovation, sustainability, and global competitiveness. Strengthening the curriculum, enhancing practical training, fostering industry–academia collaboration, and promoting digital, welfare-oriented, and entrepreneurial approaches are essential to align education with contemporary industry needs. Establishing Poultry Science as an independent and well-resourced discipline across all universities will ensure the development of technically competent graduates capable of addressing emerging challenges and harnessing new opportunities. By embracing modern reforms and forward-looking strategies, Poultry Science education can significantly contribute to national food security, rural development, employment generation and reinforce India's leadership in the global poultry domain.

## Reference

References available upon request.

LP-17

# Data-driven Poultry Management

**Alokesh Ghosh**

Centre for Development of Advanced Computing

Conventional poultry management practices, which rely heavily on manual observation and reactive interventions, often result in sub-optimal resource utilization, inconsistent welfare compliance, and delayed identification of pathogenic or production-limiting events. These limitations are becoming more pronounced amid rising global demand for poultry products and increasingly stringent regulations related to sustainability, biosecurity, and traceability.

In India, one of the world's largest and fastest-growing poultry producers, sector-specific challenges such as extreme climatic variability, fragmented farm structures, feed price volatility, and stringent export-quality requirements further complicate operational efficiency. Consequently, the adoption of scalable, cost-effective digital technologies is essential for enhancing process control, enabling evidence-based compliance, and meeting national and international standards for food safety and supply-chain transparency.

A range of emerging technologies has the potential to fundamentally transform the poultry sector:

- **Sensor-rich environments** enable continuous monitoring of microclimate, bird activity, feeding behaviour, and welfare indicators.
- **Internet of Things (IoT) platforms** consolidate data from distributed sensors into unified dashboards, enabling real-time, low-latency decision-making, even in remote or rural settings.
- **Machine Learning (ML) and Artificial Intelligence (AI)** facilitate early anomaly detection—including signs of disease, heat stress, environmental deviations, and feed intake abnormalities—while modelling flock density, ventilation, and performance trends.
- **Computer vision systems** automate the detection of gait abnormalities, feather pecking, flock movement patterns, etc.
- **Digital twins** provide virtual models of poultry houses, allowing simulation of growth trajectories, disease spread, ventilation strategies, and energy optimization prior to implementing interventions in the physical facility.
- **Blockchain-based traceability systems** reinforce consumer confidence by ensuring transparency in food safety, antibiotic stewardship, and sustainability practices.

India has the opportunity to leapfrog directly to affordable, scalable digital poultry systems by converting the constraints into innovation drivers. Such advancements will contribute to a resilient poultry ecosystem capable of meeting future demands in food safety, climate adaptation, and disease preparedness.

For India, the path forward is clear:

**Harness data. Empower farmers. Strengthen food security. Build a sustainable and resilient poultry ecosystem.**

LP-18

# Current status of HPAI and its global control strategies

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ICAR-National Institute of High security Animal Diseases, Bhopal - 462022 M.P.

## Introduction

Avian influenza viruses (AIVs) represent significant challenges to global public health systems due to their widespread circulation and high mortality rates. AIVs, which belong to the influenza A genus, have an eight segments genome and encode at least 11 different proteins, including hemagglutinin (HA) and neuraminidase (NA) glycoproteins. HA and NA in avian species are classified into 16 and 9 subtypes, respectively. AIVs are categorized into two groups based on their pathogenicity to chickens as determined by the intravenous pathogenicity index (IVPI) test: highly pathogenic avian influenza viruses (HPAIV) and low pathogenic avian influenza viruses (LPAIV). In recent years, the transmission of HPAIV strains such as H5N1, H5N8, and H7N9 has presented substantial threats to public health. Among the various HPAIV strains, the H5N1 virus is regarded as the most pathogenic, with a high mortality rate in chickens and humans.

The current global outbreak of HPAI H5N1 among animals has brought urgent attention to the need for a comprehensive understanding of this virus and its implications for public health. With increasing reports of human infections and the potential for devastating consequences, it is imperative to delve into the intricacies of HPAI H5N1 in order to effectively respond to the ongoing outbreak among animals, mitigate its impacts, and prevent future outbreaks and transmission to humans.

## History and Global status of H5N1 HPAIV:

The highly pathogenic avian influenza (HPAI) H5N1 virus has undergone significant evolution since its initial detection in 1959 during an outbreak in domestic poultry in Scotland. In 1996, highly pathogenic avian influenza H5N1 virus (A/goose/ Guangdong/1/1996) was first identified in domestic waterfowl in Southern China. In 1997, the first documented human transmission occurred during an outbreak in Hong Kong, affecting 18 individuals and causing six fatalities, thereby signaling the zoonotic potential of the virus In 2002, Gs/Gd-like viruses jumped again from wild birds to poultry and back to wild birds in the Qinghai Lake region. In 2003, H5N1 re-emerged in China and established in wild and domestic bird populations across Europe, Asia, and Africa.

The hemagglutinin (HA) gene of the virus diversified into 10 major genetic groups (clades – 0 to 9) and many subclades. Over the years, there have been multiple waves of intercontinental transmissions caused by the GS/GD lineage viruses through migratory birds. In 2005–2006, clade 2.2 H5N1 virus spread out from Qinghai Lake of China to other countries in Europe and Africa. In 2008, its presence further extended into multiple regions of the African continent. In 2009–2010, clade 2.3.2.1 H5N1 virus affected Asia and Europe. Between 2014 and 2016, H5 viruses diversified further into clade 2.3.4.4 in Asia, Africa, Europe, the Middle East and North America and H5N6 and H5N8 virus subtypes emerged. Between 2018 and 2020, H5N6 and H5N8 viruses

were predominant globally. The H5 HA diversified further into clade 2.3.4.4b which becomes predominant in Asia, Africa, Europe, and the Middle East. Since late 2020-2021, a new H5N1 virus belonging to clade 2.3.4.4b with a wild bird adapted N1 NA gene emerges.

The current pandemic of H5N1 virus started from 2020 and is spreading rapidly across the continents. H5N1 virus is expanding its geographic range to new continents such as North and South America. In the current period of infection (2020-2023), mammals in 26 countries have been infected: Europe (17 countries) - South America (5 countries) - North America (2 countries) - Asia (2 countries). So far, 25 countries have reported sporadic human cases of H5N1 and since 2020, human infections with HPAI H5N1 have been reported in over 23 countries, with a case fatality rate approaching 50%, highlighting the severe clinical outcomes associated with these infections.

**H5N1 panzootic in mammals**

While rare, mammals can be infected with H5N1 viruses. Reports of these sporadic infections in mammals have occurred globally amid widespread outbreaks of bird flu infections in wild birds and poultry. Mammals can be infected with H5N1 bird flu viruses when they eat infected birds, poultry, or other animals and/or if they are exposed to environments contaminated with virus. Spread of H5N1 bird flu viruses from mammal to mammal is thought to be rare, but possible.

HPAI A (H5N1) clade 2.2 virus infections of mammals have been recognized since 2003–2004. Since 2016, HPAI H5N1 viruses of clade 2.3.4.4b have been associated with global spillover events involving wild and domestic mammals. Certain genotypes, especially circulating in wild birds, have been associated with increased frequency of infections in non-human mammals. Numerous spill-over infections to wild carnivores, farmed fur animals such as cows, goats, mink, fox and raccoon dogs, and marine mammals such as sea lions were associated with clade 2.3.4.4b viruses. Pets especially cats have been infected and cat to cat transmission reported. Even though seroconversion is reported in dogs but no evidence of dog to dog transmission has been reported. Globally, sporadic H5N1 virus infections in mammals have been reported across the continents of Asia, North America, South America, and Europe. The 2024 US dairy cattle outbreak has developed into an ongoing problem for cattle, poultry and farm workers.

**Indian situation**

Outbreaks of H5N1 virus in poultry and other birds are reported continually every year and cause huge economic loss to the poultry industry. Since the first report in February, 2006, India has reported more than 400 outbreaks of HPAI due to H5N1 and H5N8 viruses in domestic poultry, water birds and wild/migratory birds. So far, two cases of human infection of H5N1 virus in India have been reported one each from Haryana and Andhra Pradesh in 2021 and 2025 respectively. The H5N1 viruses isolated from 2006-2010 belonged to clade 2.2. In 2011, outbreaks of H5N1 virus were reported in Tripura and Assam and molecular characterization of these viruses revealed introduction of a new clade 2.3.2.1a and this virus remains in circulation till today. Outbreak of clade 2.3.2.1c H5N1 virus were reported from Kerala, Chandigarh and Uttar Pradesh during the period Nov. 2014 to March 2015 and the virus has not been reported in India since then. The first outbreak of H5N8 virus belonging to a new phylogenetic clade 2.3.4.4b was reported in the zoological park of Delhi and subsequently in

six other states during October-December 2016. During the year 2020-21, India experienced a large scale outbreak of H5 subtype the viruses belonged to clade 2.3.4.4b of H5N1 and H5N8 subtypes that affected 14 states spread across India. While all the H5N8 viruses belonged to clade 2.3.4.4b, the H5N1 viruses belonged to both clade 2.3.2.1a and 2.3.4.4b. In 2024, India reported mammalian infection of H5N1 virus in tigers and leopards in the State of Maharashtra and subsequently, in Uttar Pradesh. Other mammalian species affected include Domestic Cats, Jungle cats and Lions. Vultures were also found positive for the first time in India in 2025. In 2025, India has reported outbreaks of H5N1 viruses across 12 states viz. Maharashtra, Rajasthan, Goa, Chhattisgarh, Jharkhand, Andhra Pradesh, Madhya Pradesh, Telangana, Karnataka, Bihar, Uttar Pradesh, and Odisha.

**Control strategies for H5N1 virus**

***Stamping out:*** Controlling outbreaks of HPAIVs in poultry using stamping out strategy is a reliable and proven method. The major advantage of stamping out policy is reduction of the time required for eradication of virus infection. However, with the industrialization of the poultry rearing, implementation of the stamping out policy for control of outbreaks of avian influenza virus involved culling of large number of apparently healthy birds to break the chain of transmission. There are also concerns of permanent loss of native breeds of chicken adapted to the local conditions.

***Vaccination:*** Vaccination against HPAI may be implemented as an emergency or preventive strategy. There are three main vaccine production methods against influenza: egg-based, cell-based, and recombinant vaccines. The most common are egg-based vaccines (inactivated and live attenuated vaccines). Inactivated and live attenuated vaccines have been widely used. Live recombinant virus vectors viz. turkey herpesvirus (HVT), fowl pox virus, adenovirus, infectious laryngotracheitis virus (ILT), and Marek's disease virus (MDV) are used to express antigens along with an inserted H5N1 gene. Currently, commercially approved bivalent or trivalent vaccines are available for use in chickens (either in ovo or at day-old). Use of heterologous vaccination of chickens in production settings helps to overcome the limitations posed by the presence of maternal antibodies. Other types of vaccines such as DNA vaccines, Virus-like particle (VLP) vaccines are still under investigation in early stages of research.

It is important to note that no vaccine guarantees optimal protection, even when antigenically matched, as vaccine efficacy can be influenced by host factors and viral evolution. Despite this, it is important to note that implementing vaccination programs in poultry production can significantly reduce the economic losses associated with mass culling of flocks, thereby enhancing food security for the human population.

***Surveillance Systems and Early Detection***

*a.* **Molecular and Serological Diagnostic Techniques:** Virus isolation and identification remain the most reliable and widely accepted methods for confirming the presence of avian influenza virus (AIV). These methods allow for accurate identification of epidemic AIV subtypes, providing critical information for epidemiological surveillance and outbreak control. Real time PCR is the most commonly used diagnostic methods for diagnosis of H5N1 avian influenza virus and biosafety level 3 laboratories are recommended for H5N1 isolation.

*b.* **Implementation of Early Warning Systems:** Active surveillance in wild bird populations can be conducted through capture and sampling, facilitating virus detection in natural reservoirs. During high-risk periods-such as migratory bird seasons-it is crucial to implement serological and virological monitoring. The use of sentinel birds, especially ducks due to their high susceptibility, within flocks enhances virus detection. In poultry, syndromic surveillance has proven to be a reliable indicator of HPAI infection. Recently, environmental and genomic surveillance are gaining lot of attention as early warning tools.

### *Biosecurity Measures and Containment Strategies*

Detailed records of poultry holdings near outbreak zones-including backyard flocks-are essential for monitoring and implementing effective control measures. Additionally, thorough epidemiological investigations are necessary to identify potential transmission routes and direct or indirect contacts with other farms, enabling the design of targeted containment strategies.

### *Antiviral Therapies*

NA inhibitors such as oseltamivir (Tamiflu, oral) and zanamivir (Relenza, inhaled) have been widely used to treat influenza virus infectios in humans. These antivirals exhibit normal inhibitory activity against NA, supporting their continued effectiveness in limiting viral replication. In poultry, the use of NA inhibitors for control of avian influenza is prohibited as development of antiviral resistance due to high mutation rate of H5N1 may pose a challenge to current treatment strategies.

## Conclusions

From an economic standpoint, HPAI outbreaks have had a devastating impact on the global poultry industry. Expanding zoonotic influenza surveillance systems in both animals and humans within the One Health framework is vital for early detection and prevention of emergence of H5N1 viruses. Epidemiological, virological, and pathogenesis research must also be enhanced to generate evidence-based risk assessments and timely pandemic alerts. In parallel, the development of universal influenza vaccines and new antivirals represents a promising strategy to improve protection and reduce future pandemic impacts on global public health.

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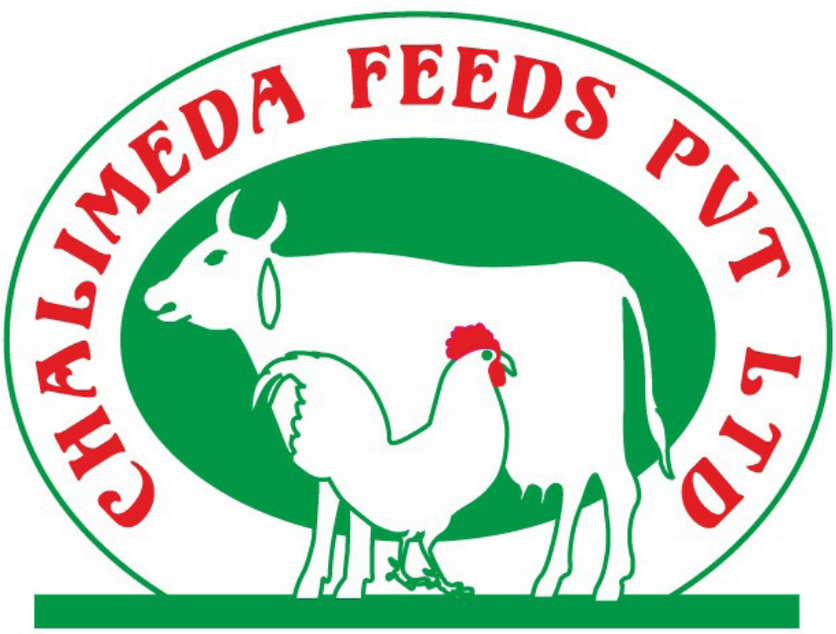


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| AGE DAYS | WEIGHT MALES | WEIGHT FEMALES | WEIGHT AVERAGE | FEED PER B/D | FEED PER B/WK | FEED PER B/CUM | FCR | MORTALITY |
|---|---|---|---|---|---|---|---|---|
| 7 | 143 | 137 | 139 | 17 | 119 | 119 | 0.9 | 0.75 |
| 14 | 325 | 286 | 306 | 28 | 196 | 315 | 1 | 1 |
| 21 | 585 | 520 | 553 | 55 | 385 | 700 | 1.3 | 1.25 |
| 28 | 910 | 780 | 845 | 85 | 595 | 1295 | 1.5 | 1.3 |
| 35 | 1300 | 1105 | 1203 | 110 | 770 | 2065 | 1.7 | 1.35 |
| 42 | 1885 | 1495 | 1690 | 130 | 910 | 2975 | 1.8 | 1.5 |
| 49 | 2340 | 2015 | 2178 | 155 | 1085 | 4060 | 1.9 | 1.7 |

## INDBRO RAINBOW ROOSTER

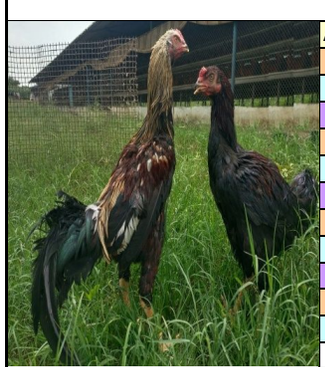
| Age | Weight | | | Feed Bird | | Cumulative | | |
|---|---|---|---|---|---|---|---|---|
| wks | Males | Females | Average | Per Day | Week | Feed | Fcr | Mortality % |
| 1 | 110 | 105 | 107 | 15 | 105 | 105 | 0.98 | 0.75 |
| 2 | 250 | 220 | 235 | 25 | 175 | 280 | 1.19 | 1 |
| 3 | 450 | 400 | 425 | 50 | 350 | 630 | 1.48 | 1.25 |
| 4 | 700 | 600 | 650 | 75 | 525 | 1155 | 1.78 | 1.3 |
| 5 | 1000 | 850 | 925 | 100 | 700 | 1855 | 2.01 | 1.35 |
| 6 | 1450 | 1150 | 1300 | 125 | 875 | 2730 | 2.1 | 1.5 |
| 7 | 1800 | 1550 | 1675 | 150 | 1050 | 3780 | 2.26 | 1.7 |
| 8 | 2200 | 1900 | 2750 | 160 | 1120 | 4900 | 2.28 | 1.9 |

## INDBRO BROWN LAYER

| | |
|---|---|
| Age at Maturity | 140days |
| Age at 50% Production | 154days |
| Age at Peak Production | 190days |
| Peak Production | 93% |
| Hen Housed eggs to 80weeks | 350eggs |
| Color of Eggs | Dark Brown |
| Average Egg weight | 60gms. |
| Body weight at maturity | 1650gms |
| Body weight at end | 2.2kgs |
| Feed to 20weeks | 7kg |
| Feed consumption during Lay | 120gms/day. |

## INDBRO ASEEL

ASEEL- PERFORMANCE



| AGE DAYS | MALES | FEMALES | AVERAGE | FEED/D | FEED/WK | CUM FEED | FCR | MORTALITY |
|---|---|---|---|---|---|---|---|---|
| 7 | 90 | 80 | 85 | 12 | 84 | 70 | 0.824 | 0.75 |
| 14 | 170 | 140 | 155 | 18 | 126 | 196 | 1.265 | 1 |
| 21 | 270 | 230 | 250 | 25 | 175 | 371 | 1.484 | 1.3 |
| 28 | 380 | 330 | 355 | 37 | 259 | 630 | 1.775 | 1.4 |
| 35 | 500 | 440 | 470 | 45 | 315 | 945 | 2.011 | 1.5 |
| 42 | 680 | 600 | 640 | 54 | 378 | 1323 | 2.067 | 1.6 |
| 49 | 900 | 780 | 840 | 65 | 455 | 1778 | 2.117 | 1.7 |
| 56 | 1060 | 940 | 1000 | 79 | 553 | 2331 | 2.331 | 1.8 |
| 63 | 1250 | 1130 | 1190 | 94 | 658 | 2989 | 2.512 | 1.9 |
| 70 | 1450 | 1330 | 1390 | 105 | 735 | 3724 | 2.679 | 2 |
| 77 | 1650 | 1530 | 1590 | 120 | 840 | 4564 | 2.87 | 2.1 |
| 80 | 1770 | 1650 | 1710 | 133 | 399 | 4963 | 2.902 | 2.2 |

LCC - layer chick crumps

Layer grower or scavenging after 6 weeks.

FEMALES

| AGE AT MATURITY | EGGS PER YEAR | WEIGHT AT MATURITY | WEIGHT END OF LAY |
|---|---|---|---|
| 147DAYS | 160 | 1700GMS | 1900GMS |

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| Total Ash | Max. | 32 - 35.0% |
| Crude Fibre | Max. | 2.0% |
| Calcium | Min. | 9.0 - 10.0% |
| Phosphorous | Min. | 4.5 - 5.0% |
| Sand & Silica | Max. | 2.5 - 3.0% |
| Lysine | Min. | 2.0% |
| Methionine | Min. | 0.6% |
| Pepsin Digestibility | Min. | 85.0% |
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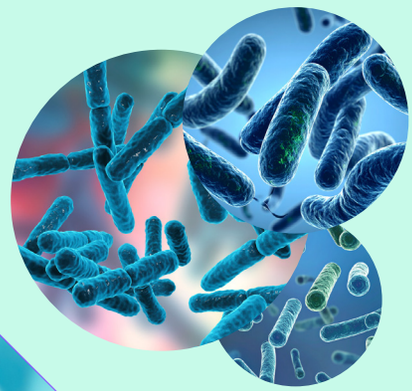

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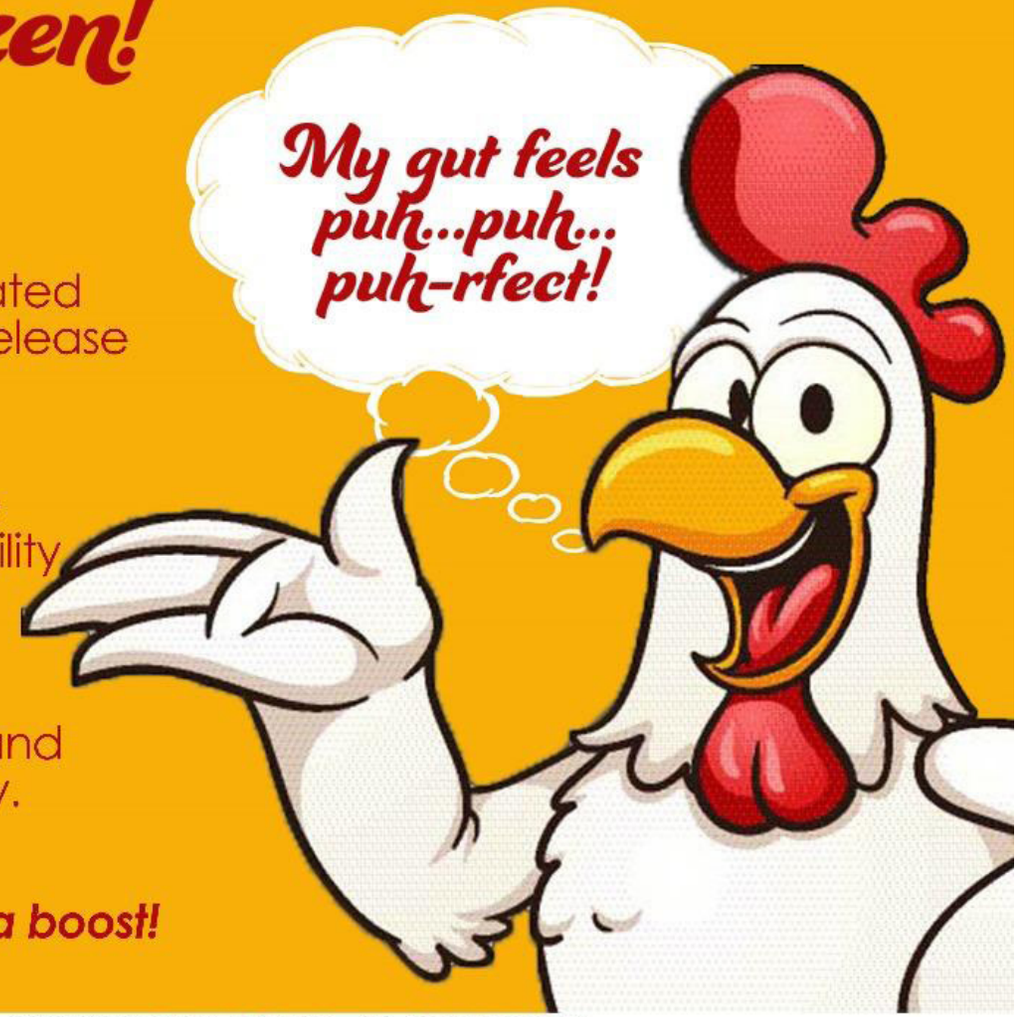


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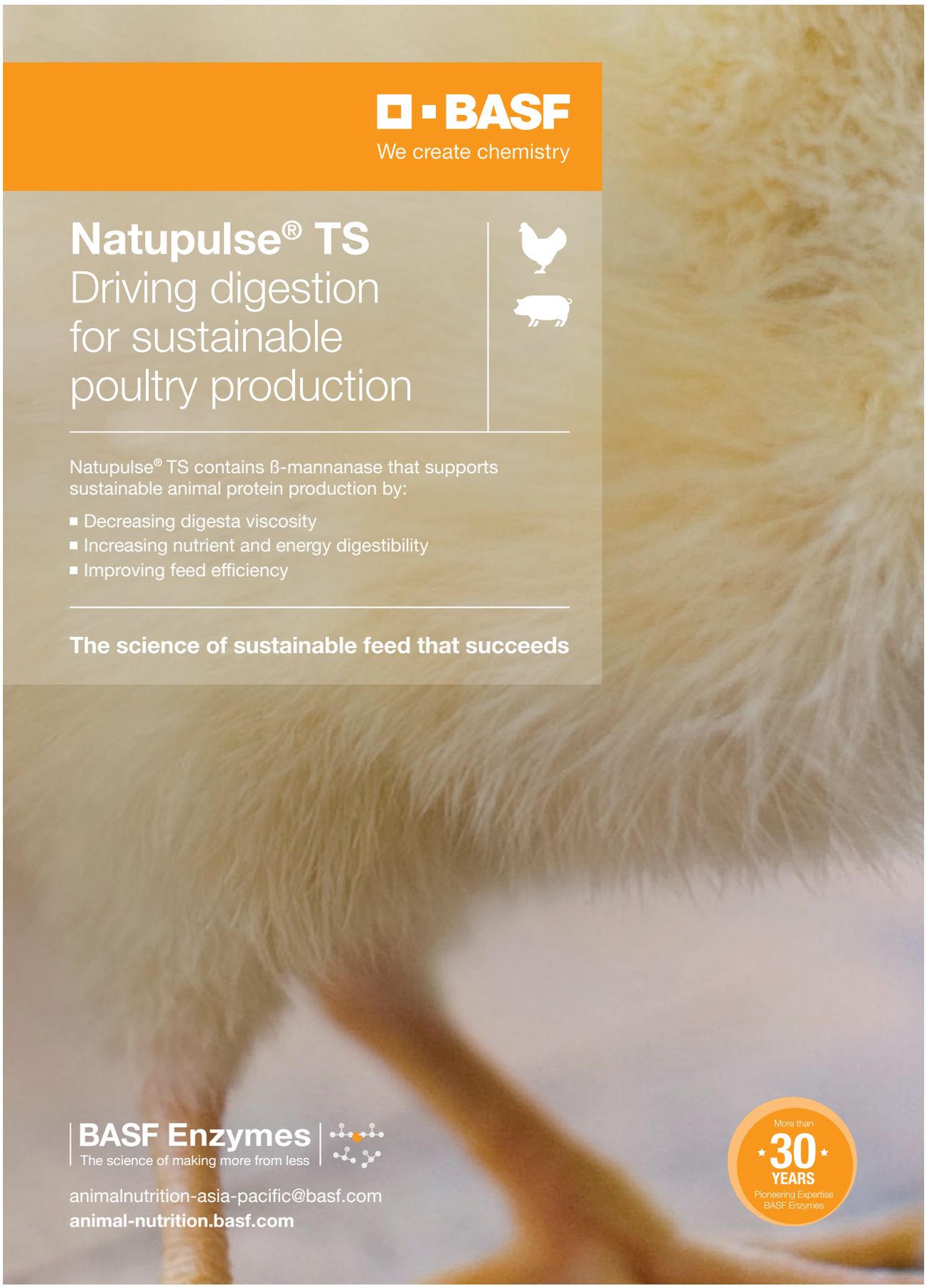
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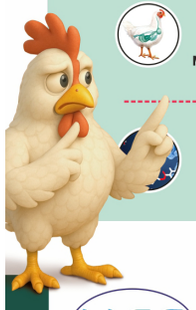

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- Infrastructure facilities: Abattoir, Meat processing plant and office space for start-ups
- Business development and networking opportunities
- Information on regulatory requirements
- Skill development & Capacity building programmes for start-up incubatees
- Facilitate marketing assistance

The Journey so far...

### Our Clients portfolio

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## DPR Offers....

## Rural Poultry Technologies

### Vanaraja

- Dual purpose
- 100-110 eggs/year (backyard)
- Egg colour - Brown
- Body weight-1.8-2.0kg at 3m

### Srinidhi

- Dual purpose
- 140-150 eggs/year (backyard)
- Egg colour - Brown
- Body weight-1.7-2.0kg at 3m

### Janapriya

- Dual purpose
- 140-150 eggs/year (backyard)
- Egg colour - Brown
- Body weight -1.2-1.5kg at 3m

### Gramapriya

- Layer (egg) purpose
- 160-180 eggs/year (backyard)
- Egg colour - Brown
- Body weight-1.6-1.8 kg at 3m

### Krishilayer

- Layer (commercial) purpose
- 270-290 eggs/year (Farm)
- Egg colour- White
- 1.8-2 kg feed/ dozen eggs

### Krishibro

- Broiler (meat) purpose
- 1.4-1.5 kg at 6 week
- FCR - 2.0
- Coloured broiler bird

### Aslibro

- Broiler (meat) purpose
- 1.5-1.7 kg at 3 month
- FCR - 2.6
- Coloured broiler bird


### Vanashree

- Dual purpose
- 170-180 eggs/ year
- Egg colour - Brown
- Body weight-1.8-2.2 kg at 5m

## Native Chicken

### Aseel

- 60-70 eggs/ year
- Body weight:1.8-2.0 kg at 5m

### Kadaknath

- 150-170 eggs/ year
- Body weight:1.4-1.6 kg at 5m

### Ghagus

- 110-118 eggs/ year
- Body weight:1.8-2.0 kg at 5m

### Nicobari

- 170-180 eggs/ year
- Body weight:1.3-1.5 kg at 5m

## AICRP Developed varieties

Pratapdhan

Narmadanidhi

Kamrupa

Jharsim

Himsamridhi

Tokbari


**ICAR-Directorate of Poultry Research**
Rajendranagar, Hyderabad - 500 030, India


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DEPARTMENT OF FISHERIES
सत्यमेव जयते

एन एफ डी बी
NFDB
NATIONAL FISHERIES DEVELOPMENT BOARD

# NATIONAL FISHERIES DEVELOPMENT BOARD

## About us:

- The National Fisheries Development Board (NFDB), an autonomous organization established on 10th July 2006, under the Ministry of Agriculture, Government of India, to increase fish production and productivity and to coordinate fishery development in the country.
- At present, functioning under the Department of Fisheries (DoF), Ministry of Fisheries, Animal Husbandry and Dairying (MoFAHD), Government of India. NFDB undertakes various developmental activities to enhance fish production, productivity, and post-harvest infrastructure in fisheries sector.

## Our Mission:

- Development of the fisheries sector by enhancing fish production and productivity, ensuring nutritional security, and contributing to economic growth, employment, exports, and tourism.

## Regional Centers :

- **Eastern Regional Centre, Bhubaneswar, Odisha:** Established in 2013 within the National Freshwater Fish Brood Bank (NFFBB), it serves as a technology dissemination center to disseminate knowledge on breeding techniques, quality seed, GIFS etc.
- **North-Eastern Regional Centre, Guwahati, Assam:** Set up in 2014, it promotes fisheries and aquaculture in the North-Eastern region through training, awareness, and technical support.
- **Integrated Coastal Aquaculture Facility, Mulapolam, Andhra Pradesh:** Developed in 2024 with nursery complexes, grow-out ponds, and a water management system for brackish water aquaculture.

## Key Schemes/Projects implemented

**Pradhan Mantri Matsya Sampada Yojana (PMMSY) 2020-21 to 2025-26:**

A flagship scheme to bring about Blue Revolution through sustainable and responsible development of fisheries sector in India with an investment of Rs. 20,050 crores.

**National Fisheries Digital Platform (NFDP):**

transformative initiative under the ongoing PM-MKSSY scheme to lay the foundation through a comprehensive framework for data collection and analysis, to facilitate informed decision-making, need-based policy formulation, partnerships and collaborations.

**Group Accident Insurance Scheme (GAIS):**

Insurance coverage to fishers and other individuals involved in fishing-related activities in case of accidental death, permanent/partial disability, and hospitalization due to accidents.

**Aquaculture Insurance under PM-MKSSY:**

provides a one-time incentive for adopting insurance for aquaculture farms. The insurance is intended to protect against unforeseen losses, particularly for those engaged in newer forms of aquaculture, and includes systems such as cage culture, Circulatory Aquaculture System (RAS), bio-floc, and raceways.

**Entrepreneur model under PMMSY:**

promoting entrepreneurs, start-ups, and private entities by providing back-ended subsidy upto 30% of the project cost.

**Fisheries and Aquaculture Infrastructure Development (2023-24 to 2025-26):**

Facilitates creation of fisheries infrastructure facilities both in marine and inland fisheries sector.

- Provides interest subvention upto 3% of project cost with a maximum repayment period of 12 years including moratorium of 2 years on principal amount

**Pradhan Mantri Matsya Kisan Samridhi Sah-Yojana (PM-MKSSY) 2023-24 to 2026-27:**

A sub-scheme under the PMMSY to address structural weaknesses in the fisheries sector through targeted financial and technological interventions, facilitating institutional reforms and supporting the long-term transformation.


**For further details:**
National Fisheries Development Board
Toll Free No: 1800-425-1660
Open: Monday to Friday (10:00 AM - 6:00 PM)
Email: info.nfdb@nic.in

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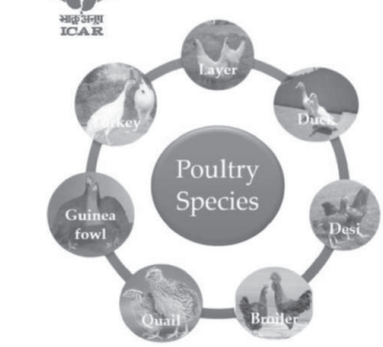
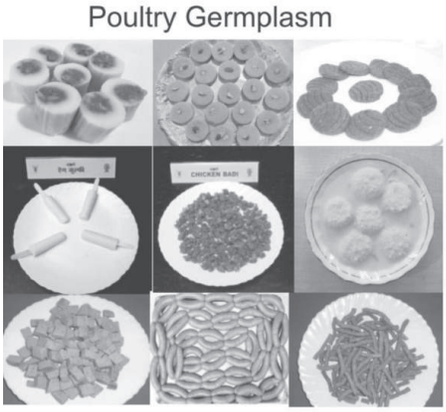



Poultry Germplasm



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- Management Tools
- Feed Formulation
- Organic Poultry Farming
- Breeding Flock Management
- Poultry Health Care
- Poultry Meat/Egg Processing
- Poultry Waste Management

**Our Support**

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Marketing strategies
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**ABI Core Activities**

Incubation Services, Consultancy Services, Business Development Support, Capacity Building & Training, Upscaling Technologies, Intellectual Property Management

Contact: Dr Sandeep Saran, PI - ABI, Tel: 0581-2300948, 9412823436; Email: ssaran1965@gmail.com


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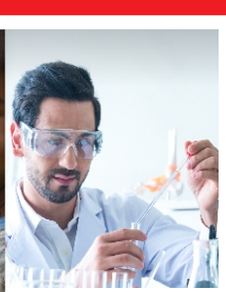


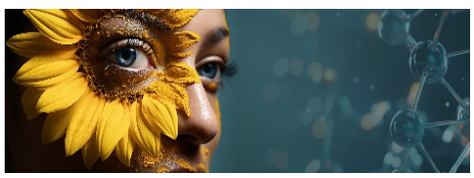





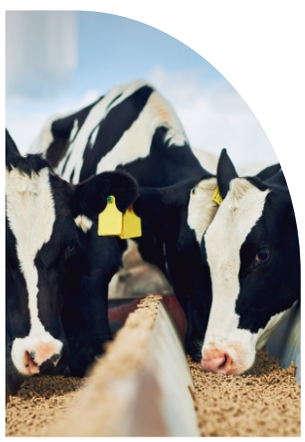


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## Rural PoultryTechnologies

### Vanaraja™

- ❖Attractive feather colour pattern
- ❖Dual purpose with low inputs
- ❖Produce upto 110-120 eggs in free range
- ❖Better survival rate

### Native chicken

- Aseel
- Kadaknath
- Vanashree
- Ghagus
- Nicobari

### Gramapriya ™

- ❖ Tinted brown egg layer
- ❖ Produce 160- 180 eggs in free range
- ❖Better adaptability to backyards
- ❖Better survivability

### Srinidhi

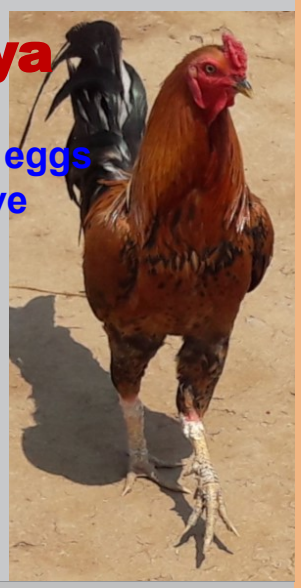
- ❖ A promising dual purpose variety
- ❖Longer shanks
- ❖Produce about 150 eggs in free range
- ❖1.5-1.8 kg at 12 weeks of age

### Krishibro ™

- ❖Broiler with multicolored plumage
- ❖1.6 kg body weight in 6 weeks
- ❖Suitable for small scale intensive farming
- ❖Good organoleptic quality of meat

### Janapriya

- Dual purpose
- Produce 140-150 eggs
- Presence of native inheritance



### AICRP varieties

- Pratapdhan
- Kamrupa
- Narmadanidhi
- Jharsim
- Himsamridhi


भाकृअनुप ICAR

**ICAR Directorate of Poultry Research**

Rajendranagar, Hyderabad 500 030, India

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