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Review Article

Enteric Infections in Poultry: A Review

Dr. Preeti Godara[1], Dr. Manisha[2] and Dr. Balwant Kumar[3]
1Assistant Professor, Department of Veterinary Microbiology
2Teaching Associate, PGIVER, Jaipur
3Assistant Professor, Department of Veterinary Physiology
Shekhawati Veterinary College, Sikar, Rajasthan
***Corresponding Author:** pritigodara355@gmail.com
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Abstract:

The poultry industry in India, faces significant challenges due to disease outbreaks, particularly poultry enteritis, which leads to considerable economic losses. Despite being one of the top global producers of eggs and poultry meat, India's per capita consumption of these products remains lower than recommended levels, highlighting inefficiencies in production and consumption. Poultry enteritis, primarily caused by enteric viruses such as Avian Coronavirus (ACV), Chicken Astrovirus (CAstV), Fowl Adenovirus-I (FAdV-I), and Chicken Parvovirus (ChPV), significantly impacts poultry health by causing symptoms such as delayed growth, lethargy, and reduced feed intake. This study, conducted in four major districts of Rajasthan (Ajmer, Pratapgarh, Dungarpur, and Sirohi), reveals a high prevalence of these enteric viruses, with mixed infections being common. Concurrent bacterial infections, notably *Salmonella* and *Escherichia coli*, were frequently detected in infected poultry, exacerbating the disease. The prevalence of these pathogens and their association with antibiotic resistance pose significant challenges for treatment. Additionally, while there is currently no vaccine for enteric viruses in poultry, emerging vaccine platforms, such as Outer Membrane Vesicle (OMV)-based vaccines, offer promising solutions. OMV vaccines have shown potential in inducing specific immune responses and may provide an alternative to conventional antibiotic treatments. The study underscores the need for improved biosecurity, disease management strategies, and further research into novel vaccine platforms to address the growing concerns of poultry enteritis in India's rapidly expanding poultry industry.

Keywords: Poultry enteritis, Outer membrane vesicles, Vaccine

Introduction:

The poultry industry is one of the fastest-growing agricultural sectors in India due to emerging intensive

farming, globalization, and free marketing. The annual turnover of the poultry industry is about Rs. 80,000 crores (APEDA, 2015-16). It is broadly divided into two sub-sectors: one with a highly organised commercial sector holds about 80% (say, Rs. 64,000 crore) and the other with an unorganised sector holds about 20% (Rs. 16,000 crore) of the total market share, respectively. India ranks in 3rd place in the production of eggs, with 3.97 million tons of eggs, and in 6th place in poultry meat, with 2.76 million tons, as per FAO 2014. But even with the large data in production, per capita consumption of about 69 eggs and 3.35 kg of meat per person per year in 2016–2017 in India is lower than the expected 180 eggs and 10.8 kg of poultry meat per person per year as recommended by the Indian Council of Medical Research (Department of Animal Husbandry, Dairying, and Fisheries, Ministry of Agriculture, and Farmers Welfare Government of India under the National Action Plan for Egg and Poultry-2022).

In 2019, the poultry population in the country was 851.81 million, a 16.8% increase from the previous census. Commercial farms accounted for 534.74 million, a 4.5% rise, while backyard poultry reached 317.07 million, a 45.8% increase (20th Livestock Census, Department of Animal Husbandry and Dairying). Rajasthan, with a 1.10% share, ranks 18th in poultry production.

The primary reasons for production losses in the poultry industry of the country include various diseases and nutritional disorders. Reducing these issues is one of the best ways to increase per capita consumption of eggs and poultry meat (Chatterjee and Rajkumar, 2015).

Etiology of Poultry Enteritis:

Poultry enteritis is a multifactorial infectious disease impacting birds during their initial weeks of life, causing substantial economic losses to the global poultry industry. Various pathogens, including viruses, bacteria, parasites, and fungi, are linked to enteric diseases (De la Torre *et al*., 2018). Clinically, enteritis is marked by delayed growth, lethargy, low uniformity, watery diarrhoea, reduced feed consumption, and a lower feed conversion rate (Mettifogo *et al.,* 2014).

Fowl adenovirus-I (FAdV-I), chicken parvovirus (ChPV), avian coronavirus (ACV), avian rotavirus, avian reovirus, chicken astroviruses (CAstV), and avian nephritis virus are the viruses that are frequently linked to poultry enteritis. Enteric viruses mainly trigger primary damage to the host tissue, which emerges as a path for secondary agents such as bacteria (*Escherichia coli*, Salmonella, and Clostridium, among others) or parasites (*Eimeria* spp.) to invade the gastrointestinal tract (GIT), resulting in severe, irreversible damage and the emergence of clinical signs (Saraswat *et al*., 2021).

Prevalence of Enteric Viruses in Rajasthan Poultry:

In 2018, we identified the problem of poultry enteritis in four major districts of Rajasthan (Ajmer, Pratapgarh, Dungarpur, and Sirohi). Samples were collected from birds that died with clinical findings of diarrhoea, dullness, and depression and investigated for viral diseases. Out of 151 samples tested, 68 (45.03%) samples were found positive for a single or combination of ACV and CAstV, which indicates that

ACV and CAstV are widely prevalent in enteritis-affected poultry flocks in the study area, and these viruses might play a role in the causation of enteritis in affected birds. A high prevalence of enteric ACV and CAstV was found in Ajmer district (67.56%), followed by Pratapgarh (41.17%), Dungarpur (28.20%), and 63 Sirohi (45.83%). This difference in frequency across Ajmer, Pratapgarh, Dungarpur, and Sirohi districts of Rajasthan might be attributed to the size of chicken flocks and the quantity of samples taken. The majority of the samples from Ajmer district were taken from commercial poultry farms, which comprise a huge number of chickens reared in a tightly restricted space. While from the other three districts most of the samples were from small flocks, close contact is relatively less likely and there is a low chance of horizontal transmission.

Enteric DNA viruses (fowl adenovirus-I, chicken parvovirus) were also found in poultry enteritis samples. FAdV-I was detected in 58 out of 151 tested samples, with a 38.41% prevalence. It was found as a single virus in 35 samples and in combination with ChPV in 23 samples. ChPV was detected in 51 of the 151 samples tested by PCR. Thus, a total of 33.77% of samples were positive for ChPV. The prevalence of enteric DNA viruses was highest in Ajmer district (75.67%), in comparison to Pratapagarh (66.66%), Dungarpur (46.15%), and Sirohi district (47.05%). Enteric viruses were found individually or as a mixed infection in the samples. Samples were found to be mixed, i.e., FAdV-I + ACV, ChPV + ACV, FAdV-I + CAstV, CAstV + ACV, and FAdV-I + ChPV + ACV.

Prevalence of Enteric Bacteria in Rajasthan Poultry:

Enteric viruses may impair mucosal immunity in the intestines. Due to this, bacterial agents like E. coli and Salmonella spp. had the opportunity to invade GIT. This impaired development may be due to nutritional deficiencies caused by decreased feed absorption or direct infection of immune organs (Koo *et al*., 2013). The prevalence of concurrent bacterial infections in intestinal samples was found to be Salmonella 80.23%, E. coli 73.25%, Proteus 53.48%, and Klebsiella 36.04%. The highest prevalence of Salmonella was found in our study. It was observed in the present work that the majority of the concurrent bacterial isolates were resistant to cefixime, kanamycin, tylosin, clarithromycin, ciprofloxacin, azithromycin, ampicillin, and tetracycline, while susceptible to gentamicin, ceftriaxone, amikacin, and chloramphenicol.

Salmonella Infections in Poultry and Public Health Concerns:

As poultry production in India and Rajasthan in particular has grown significantly in the last 10–20 years, a study on the prevalence and distribution of enteric viruses and other pathogens (bacteria and protozoa) will definitely help in determining the risk assessment for the poultry industry in the area. Further antibiotic sensitivity testing will provide guidelines for the treatment and management of enteric disorders. At present, there is no vaccine available for use in commercial broiler chickens against enteric viruses; strict biosecurity measures remain the only available option for their control. Vaccine control is

the mainstream approach to combating these infections.

Salmonella infections are a source of concern for the global poultry business as well as a risk to human health and safety across the world. The present strategy is mostly based on the use of antibiotics against salmonella (Feasey, 2012). However, antibiotic misuse in poultry enterprises has resulted in low efficacy and a significant problem with antibiotic residue contamination (Wiss *et al*., 2018). In manufacturing, inoculation using vaccines is frequently required to achieve a protective response against these bacteria.

Current and Future Approaches to Vaccine Development:

Commercially available *Salmonella* vaccines for poultry can broadly be divided into killed or inactivated vaccines and live vaccines that have major disadvantages in the poultry industry. The major concern regarding the available live *Salmonella* vaccines for poultry is the ability of the live vaccine strain to revert to its virulent form (Stewart-Brown, 2019). Moreover, killed vaccines are known to elicit a lower cell-mediated immunity and a shorter length of protection; hence, they are more likely to require boosters. In contrast, live vaccines can elicit both cell-mediated and humoral immune responses and rarely require a booster. The commercially available killed vaccines for *Salmonella*, POULVAC® SE and POULVAC® SE-ND-IB, are intended for broiler and/or layer use, and their administration route is an intramuscular injection. Likewise, two commercially available live vaccines, POULVAC® ST and SALMOVAC® SE, are intended for broiler and/or layer use, and their administration route is either spray or oral administration (Acevedo-Villanueva *et al*., 2021).

Outer membrane vesicle-based vaccines have various potential benefits over live attenuated vaccines, including high immunogenicity without replication, increased safety, and improved intrinsic adjuvant effects, making them a unique candidate for treatment against bacterial infections (Mitra *et al*., 2012).

In 2023, we isolated OMV from Salmonella strains and used that OMV as a vaccine for immunisation in a chicken model. Vaccination significantly induced serovar-specific antibodies after post-immunisation. Importantly, OMV-based vaccines are a potential platform for vaccine development against various bacterial infections. Conclusively, OMV-based vaccines are the future of antibacterial vaccine development (Kashyap *et al*., 2022).

Conclusion:

The rapid growth of the poultry industry in India, particularly in Rajasthan, has been accompanied by increasing challenges related to poultry diseases, especially enteritis, which is caused by a combination of viral and bacterial pathogens. Our study highlights the significant prevalence of enteric viruses, including *Avian Coronavirus* (ACV), *Chicken Astrovirus* (CAstV), and *Fowl Adenovirus-I* (FAdV-I), in poultry flocks across Rajasthan, with mixed viral infections commonly observed. These viruses impair mucosal

immunity in the gastrointestinal tract, facilitating secondary bacterial infections such as *Salmonella* and *Escherichia coli*. The high prevalence of antibiotic-resistant bacterial strains further complicates the treatment and control of these infections.

The findings of this study emphasize the need for effective disease management strategies in the poultry industry. While biosecurity measures are currently the primary means of controlling enteric diseases, the absence of vaccines for these viral pathogens remains a major gap. The development of new vaccine platforms, particularly *Outer Membrane Vesicle* (OMV)-based vaccines, offers promising prospects for mitigating both viral and bacterial infections. OMV vaccines have demonstrated high immunogenicity and safety, making them a potential alternative to traditional vaccination methods, particularly in addressing antibiotic resistance issues in poultry farming.

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