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Review Article

Review on consequences of COVID-19 outbreak on the poultry sector

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Abstract

Poultry production, health, and immunity are some of the factors that can encounter upcoming poultry sector growth. Consumer confidence, quality of product and safety and type of product, and the diseases, which are emerging and re-emerging will be continuing to be the main challenges to the present situations and the industry's strategic future. Zoonotic and foodborne infections and diseases are firmly associated with the poultry industry. Elimination, control of zoonotic diseases, eradication, and foodborne pathogens present a key challenge to the industry of poultry. Furthermore, the hazards to public health by consuming food with higher residues of antibiotics will stay a life-threatening concern. Poultry production theory explained here in a short review not only be restricted to overlook control of the disease. Somewhat, this will also include the interconnection of animal immunity, health, and welfare. It is important to keep in view that chicken is not prone to intra-nasal infections by COVID-19 (SARS-CoV-2) pathogen. However, the pandemic of COVID-19 will be affecting the consumption of poultry, transportation, and the economy of poultry farming. This will also draw attention to its, social dimension, economy, ethics, and the sustenance of the achievement of the highest ecological safety. This review aims to explore these main tasks in detail, ensuring the industry's sustainable growth and ecological safety. Chain partners need to be more involved in present and future planning to fulfill human demand.

Background

The poultry industry is an important component of the global food system, with a significant contribution to the economy and the livelihoods of millions of people. However, poultry production is also faced with numerous challenges such as diseases, food safety concerns, and environmental impact. In recent times, the outbreak of the COVID-19 pandemic has resulted in significant disruptions to the poultry industry with an impact on trade, transportation, and consumption. In order to address these challenges and ensure a sustainable future for the poultry sector, it is important to have a comprehensive understanding of poultry production theory. This theory encompasses several factors such as animal health and immunity, disease control, welfare, and environmental sustainability, among others. Control of diseases, higher production, quality of products, and reasonable cost of production have been the current key goals of the industry of poultry. Henceforth, human welfare necessities, and meeting per capita consumption, goal-oriented and continuous efficient health care for the spread of disease, control, and reduce the applications of antibiotics [1]. These activities will consist of the launching of strategies to control the disease which are infectious, face continuous fluctuations in social and political situations, address perceptions of consumers regarding the welfare of animals, and ensure the security and safety of foods and ecological security problems. Furthermore, the constant rise in the feedstuff cost and thus foods and feeds remain noticeable problems [2]. The occurrence of novel and unanticipated infections and new legislation in some nations will also persist as important problems.

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Food challenges

Perspectives of consumers on the safety and quality of products of animals are a constant matter for the industry of poultry and its strategic future [3,4]. Through the food chain, several foodborne illnesses can spread. In some previous reviews, *Campylobacter* spp. and *Salmonella serovars* are the microbes involved in poultry which are more often responsible for food-borne diseases in humans. Furthermore, concerns about public health on the development of resistant bacteria due to antibiotic abuse as promoters of growth and drugs are developing challenges in public health. Control of food-borne pathogens and zoonotic diseases involves a vast knowledge and experience of how pathogenic microbes colonize and invade, as well as circumstances encouraging or stopping growth for each strain of microbe [2,4].

Campylobacter spp. is the main cause of zoonotic enteric infections globally and can contribute to food-borne illnesses. Most campylobacter infections in people are spread via the food chain. Regarding a known poultry house illness, while vertical transmission evidence is lacking, it is still open to debate. However, deceased bird intestines have been shown to contain microbes. Therefore, the main method of *Campylobacter* transmission in birds seems to be environmental horizontal transmission. Through a variety of slaughtering procedures, including de-feathering, evisceration, and transport, the external concentration of *Campylobacter* is increased per chick load [5]. The burden from production to consumption is, however, reduced by 4-5 logs due to decreases in other processing steps. Sufficient sanitary control precautions should be properly followed and employed at all stages of production. The production process should be enhanced in terms of biosecurity. An environment should be developed to keep *Campylobacter* spp. away from the chicken house if they are discovered in hygienic barriers [6]. The Food and Agriculture Organization (FAO) and World Health Organization (WHO) both incorporate scientific assessments of potential negative effects on health as well as actual adverse effects in their definitions of risk assessments. These are the primary outcomes of threat analysis, which also include risk management and the evaluation, choice, and execution of potential courses of action. Risk communications, which include the sharing of information among all parties concerned, must adhere to these guidelines [7].

The four stages of risks valuation are:

1) Hazard documentation;

2) Exposure assessment;

3) Characterization of hazard;

4) Characterization of risk

Additional significant issues include the inability of customers to handle and prepare food in a hygienic way and the processing businesses' limited ability to reduce the level of dangerous germs in animal products. Therefore, it will be necessary to develop upcoming strategies to reduce the contamination of chicken before it is delivered to processing facilities and to make sure that the effects of the COVID-19 pandemic on the global food and feed industry's supply chain are adequately taken into account.

Antibiotic challenges

Antibiotic resistance in people, animals, and microbes is currently a hot topic and a persistent threat to public health [8,9]. Public concerns about animal product safety have increased due to the use of antibiotics as growth promoters in animals' diets, and there are potential adverse effects on human immunity and health. Antibiotics can lead to changes in gut flora, resulting in increased nutrient absorption and digestion, which can enhance the amount of nutrients required for production. This is because enhanced gut ecology favors the benefits of microorganisms. On the other hand, antibiotics are making drug-resistant microorganisms more common. Since 2006, some European countries have prohibited the use of antibiotics that stimulate growth in animals raised for food. In addition, health hazards such as dysbacteriosis and clostridia-related gastrointestinal disorders are growing [10].

Multidrug-resistant bacteria are increasingly posing a serious danger to human health, animal health, and effective antibacterial therapy globally. Furthermore, the formation of antimicrobial resistance in bacteria is not guaranteed by the development or discovery of new antibiotics [11]. For instance, the multiresistant bacteria that have been increasing nosocomial infections in humans include Vancomycin-Resistant Enterococci (VRE) [12]. In southwestern Germany, the prevalence of VRE in turkey flocks is being investigated. Real-time Polymerase Chain Reaction (PCR) was used to examine the prevalence of vancomycin tolerance genes-vanA, vanB (B1/B2/B3) and vanC (C1/C2/C3)-in isolated enterococci. VRE was discovered in 15 of the 20 flocks of turkeys that were examined (75%) Dust samples have also revealed the presence of *enterococci* with van genes. 145 poultry *Enterococcus* strains have their antimicrobial sensitivity evaluated. 89 isolates exhibited resistance to three or more antibiotics. 42 (81%) of the isolates from Turkey were multi-tolerant [13]. Across all chicken production systems, tetracycline, gentamicin, and lincomycin tolerance patterns were the most prevalent [14-16].

Furthermore, broiler chicken cloacal swabs from Bangladesh were found to have multidrug-resistant *E. coli* [17]. Antibiotics are being used more often in feed-producing animals to boost their health and immunity as well as the profitability of animal husbandry during the COVID-19 epidemic. However, its usage might promote the emergence of bacteria that are resistant to antibiotics as well as the unfavorable environmental consequences of antibiotics, such as carryover effects and cross-resistance.

Diseases challenges

The emergence of diseases in animals is hastened by several factors. These factors are comprised of the structure and development of poultry farming, production cost, amplifying of global competition, and increasing the poultry and products

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movements in poultry throughout the world. This increase in movement could rise the hazards of the introduction of infections in specific regions which are declared as disease-free regions [4]. Re-emerging are those diseases, in the past have occurred which are now rapidly growing in some specific regions or in host ranges. Health disorders and infectious diseases have mostly negative impacts on the economy. Numerous infections have been linked to illnesses in poultry, either directly or indirectly through non-infectious causes, alone (mono-causal), or in combination with other germs (multi-causal). Non-infectious factors that impact chicken health include weather conditions, sanitary conditions, housing design, density, feed and water cleanliness, and the training and experience of poultry farmers [18]. These several factors can interact with one another and impact or improve an animal's state of health. To guarantee the required production output, poultry producers must implement strategies for disease management, good feeding, and husbandry practices. In order to ensure optimal chicken health, performance, and immunity as well as to prevent disease transmission, husbandry should be focused on meeting the required conditions of raising. Stress-inducing substances can impair poultry's ability to resist sickness, increase the susceptibility of hens to infections, and reduce the effectiveness of vaccinations. Viruses, parasites, bacteria, and fungi are only a few of the infectious pathogens that cause infectious illnesses in chickens and can spread and transmit them in farms by vertical or horizontal transmission [4]. Early disease transmission is primarily vertical, notably poor hatching circumstances in the hatchery and inappropriate sanitation (yolk sac infection/omphalitis). Infections such as *mycoplasma*, *E. coli*, *Aspergillus*, *Salmonella*, *Streptococci*, *Pseudomonas*, *Staphylococci*, *Hepatitis*, and *encephalomyelitis* can result from this sort of transmission. Transmissions of the various microorganisms discussed above can also take place horizontally through direct contact with animals [10]. *E. coli*, infectious bronchitis, avian influenza, infectious bursal disease, Newcastle disease, Ornithobacterium rhinotracheale, mycoplasma, and metapneumovirus are common illnesses in chickens across the world.

Avian influenza, infected bursal disease, Newcastle disease, Infectious Laryngotracheitis (ILT), coccidiosis, infectious Coryza, colibacteriosis, *E. coli*, *Salmonella* spp., infectious bronchitis, and mycoplasma are the most prevalent poultry diseases in Pakistan. Additionally, the objectives of production (breeds as well as kind, such as broilers *vs.* layers), the geographic location, hygienic conditions, seasons, and metrological factors all affect condition and disease. Avian influenza is the most dangerous disease in Pakistan and many other nations across the world because of a lack of adequate vaccines. Avian influenza often strikes in the winter, as wild migratory birds begin to pass Pakistan [19,20]. The chicken business suffers significant losses as a result of intestinal diseases brought on by infections with coronavirus, rotavirus, enteritis, *E. coli* and parasite infestation.

Respiratory diseases have been the most vital problem in the poultry industry. Clinical signs severity disease duration, morbidity, and mortality rates are variable highly and affected by virulence, pathogenicity, type of agents, aspects of the environment such as poor management, ventilation, high stocking density, litter problems, meteorological conditions, toxic gases level such as carbon dioxide, ammonia, secondary infections along with coexisting diseases. Poultry farming throughout the globe has become one unit that is interconnected. Therefore, the COVID-19 pandemic has underlined the need for understanding the greatest threat that the present pandemic virus and future microorganisms that might cause a pandemic provide. The world should establish new rules for trade, wild and domestic animal movements, and the health of animals and should offer suitable funds for research for such activities to develop strategic plans to ensure animal protein's continuous supply.

Challenges from the COVID-19 Outbreak

The COVID-19 pandemic started as an infectious disease that is posing grave and fatal risks to human health. Beta coronaviruses, such as MERS-CoV, SARS-CoV, SARS-CoV-2 and COVID-19, are enclosed viruses that are highly contagious but are easily eliminated by disinfectants and regular soap. Coronavirus is divided into groups by the proteins alpha, beta, gamma, and delta. Coronavirus is a common cause of both new and developing diseases in animals used for food production [21]. The coronavirus can negatively impact the respiratory, renal, hepatic, intestinal, and neurological systems and functions in poultry, with infectious bronchitis being the most prevalent. Lockdowns, mobility restrictions, blockage of transmission pathways, raising public awareness via online and print media, and a decrease in trade activations are all part of a preventative plan for limiting the spread of COVID-19 [22]. According to the literature, droplets, population density, weather variables, and indirect and direct contact can all limit the spread of Covid-19, but further study is required.

It is necessary to develop and implement a global plan to contain the present pandemic epidemic. Lessons learned from the COVID-19 pandemic outbreaks are innumerable and readily multiplied. The world's health must be taken into consideration and the necessity to build natural immunity as the first line of defense is the teachings that must be remembered the most. Developing a permeant vaccination or any other efficient and targeted antiviral treatment for COVID-19 virus strains would undoubtedly take some time [22,23]. In addition, there is a need for more diagnostic tools, diagnostic kits, highly qualified medical professionals, and enough hospital beds. Public education on COVID-19, its transmission, treatment, and prevention is also necessary. A lack of hospital beds, an abundance of diagnostic tools, poorly qualified doctors, and a high rate of fatalities among nurses, doctors, and other healthcare workers in 2019 brought attention to the weaknesses in the health management system. All around the world, there is a need for progress and growth in the fields of medical education, healthcare seminars, and poverty eradication. Concerning the chicken sector, a lot of emphasis has been paid to limiting and controlling Infectious Bronchitis, which is brought on by gamma coronavirus and is not humanly transmissible [19-26]. SARS-CoV cannot infect or

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damage poultry, despite the fact that COVID-19 and SARS-CoV have a similar genus and employ the same host cell receptor, the Angiotensin-Converting Enzyme 2 (ACE2) [20].

According to these conclusions, poultry is not likely to act as a reservoir for these viruses [19-25]. Infectious bronchitis causes a poultry disease that is acute, highly contagious, and infectious [26]. Infectious bronchitis is extremely contagious and causes significant financial losses in the chicken business. This virus mostly affects the respiratory system, but certain strains exhibit a change in tissue tropism and can migrate to other organs such as the proventriculus, kidneys, and oviduct [26,27]. Typically, this infection is followed by a decline in egg number and quality as well as a slowing of development rates [27,28]. Viral transmission is influenced by a number of variables, including population migration, climatic variables including temperature and humidity, and population density. The immunological systems of avian species and humans are quite diverse, therefore vaccination protocols, applications, and kinds differ even if there is a 60% genetic similarity between people and chickens. The production of vaccines for humans is crucial for preserving life and guaranteeing welfare, making it even more crucial than the production of vaccines for agricultural animals. SARS-COV did disrupt the poultry industry [21].

In order to prevent the spread of SARS-CoV to the poultry sector and any potential mutation, it is evident that hygiene standards and biosecurity at the farms must be increased [29]. The COVID-19 virus has yet only been the subject of a relatively small amount of study in the poultry sector. Trials have demonstrated that the COVID-19 virus is not at all connected to chicken, poultry products, or poultry Swayne, et al. [24]. Additionally, recent unpublished findings from the Friedrich Loeffler-Institute Germany came to the conclusion that SARS-CoV-2 intranasal infection cannot infect hens or pigs (Balkema-Buschmann, et al. 18). While fruit bats and ferrets that were infected in the same way concurrently showed up contradictory influences that are greater in fruit bats and ferrets (Personal communication) [18-29], all swab samples, organ samples, and contact animal samples were negative for SARS-CoV-2 RNA.

Poultry disease diagnosis and control

The most popular method of disease prevention is to stop disease transmission and spread by upholding tight biosecurity [26-29]. The most recent and practical example of a zoonotic disease where an effective vaccine was developed due to the route and source of early viral identification is avian influenza [26-28]. Improvements in laboratory diagnostics, which will provide sensitive, accurate, and quick disease detection and early therapy, are being made in advance investigations [26,27]. Consequently, vaccinations produced for coccidiosis, early Newcastle Disease Virus (NDV), IBD, IBV, and IBD have helped companies save billions of dollars and increase their ability to defend themselves from disease outbreaks [29]. The COVID-19 epidemic has taught us all a valuable lesson about how interconnected human health is. Therefore, it is crucial to create diagnostic instruments and kits that are reliable, quick, and economical for use on farms, and the most resources possible should be allocated to begin research in this field. Long-term treatment of poultry diseases has been an effective strategy for disease elimination, prevention, and management. Aflatoxin, cholera, and coccidiosis are a few examples of bacterial, fungal, and parasite diseases [26]. Increased investment in the poultry sector has been made possible by the prevention and control of poultry diseases in a number of developing nations with lax biosecurity and hygiene regulations. This increase in spending will enhance human welfare, raise family income, combat poverty, and provide affordable food security [2].

Few veterinary and pharmacological medicines will be legally accessible in the future to treat chickens as food-producing animals. A careful study of the processes of pathogenic organisms should be conducted in order to accurately aid in the rapid detection of bacterial infections and to develop new treatments and instruments that will aid in this therapy's ability to eliminate pathogens' detrimental effects on production and animal health [29]. After the COVID-19 pandemic, treatment methods linked to the zoonotic diseases' secondary infections should be introduced, along with alternate treatments. The first step in controlling infectious diseases is to create strong biosecurity, maintain immunity, and get vaccinations in order to stop disease introduction and subsequent dissemination. The features that are mostly focused on production and advancements in maximum chicken output, farming profitability, and feed utilization have been vigorously chosen for the poultry farming industry globally. The main factor in enhancing food safety and animal productivity is disease management, which also has an impact on human health.

Economic impact of COVID-19 on the poultry sector

The COVID-19 pandemic has had a significant negative impact on the poultry sector's economy. The poultry industry, like many other sectors, has faced challenges in the global supply chain, transportation, labor, and sales. Restrictions on movement, lockdowns, and reduced demand have resulted in a reduction in global chicken meat trading by 1% and chicken meat production by 2% [3]. This decline in production and trade is due to the disruption of supplies of poultry, feeds, eggs, and meat caused by the COVID-19 pandemic.

Chicken is a strategic and inexpensive source of animal protein and has been widely used as a cheap source of animal protein during the pandemic. However, as the COVID-19 epidemic comes to an end, other nations must seek to become self-sufficient, which will require more expenditures. Therefore, chicken meat output is expected to decline as the demand for other types of animal protein increases [4]. Eggs are another popular and nutrient-dense source of animal protein, and their consumption has grown significantly during the lockdown. Factors such as affordability, excellent nutritional content, and simple preparation have contributed to the increase in egg and meat intake [3,4]. In conclusion, the COVID-19 pandemic has had a significant negative impact on the poultry sector's economy. While the production and trade of chicken meat have declined due to the disruption of supplies and demand, egg

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and meat consumption have increased. As the pandemic ends, countries will likely seek self-sufficiency, which may result in more expenditures and a decline in chicken meat output. Thus, it is crucial to enhance the resilience of the poultry sector by investing in reliable diagnostic instruments and kits, effective disease management and control, and research in innovative treatments and therapies to help reduce the economic impacts of future pandemics.

Immunization and vaccination

A vaccine has the ability to boost immunity against infections, hence is considered one of the best immune interventions [29]. By enabling the cost-effective prevention and eradication of diseases, vaccines have always played a crucial role in the development and strategic expansion of the business [26]. Although vaccination is not the only recommended treatment for all diseases, other variables also play a significant part. Elliptically, a number of other factors, such as active and passive immunity, immune system variations among birds, flock homogeneity, bird health, dose, metrological condition, form and route of administration of vaccine, disease epidemiology, location, and vaccination cost, can affect the effectiveness of vaccines. These difficulties will be further examined in the next section.

The body of a bird is equipped with a number of defenses against diseases and for maintaining overall health. Although birds have a variety of general defense mechanisms, such as cilia in their respiratory systems, immunity is the first line of defense [28]. The COVID-19 pandemic attracted a lot of attention to vaccine research, which has since been recognized as the most effective weapon for disease control and prevention in both humans and animals. Research on the development of novel vaccines, modifications to RNA viruses, and disease epidemiology should continue in order to reduce the hazards brought on by zoonotic diseases. For the prevention, control, and elimination of illness, biosecurity, cleaning, disinfection, and vaccination against a few diseases are generally necessary. But these programs need ongoing evaluation and revision [28].

Vaccine outbreak challenges

The main cause of erroneous biosecurity and hygiene concepts is vaccination. Vaccination cannot prevent infections, although it can lessen outbreaks. The vaccine can break down for a variety of reasons, including poor storage, improper shipment, defects and errors in the delivery, and strong infectious pressure in a region. Furthermore, it is impossible to combine coccidiostat-contaminated feed with other forms of therapy or control, such as antibiotics, bacterial vaccinations, or live coccidiosis vaccines [17]. The usage and administration of a vaccine can be thwarted by a number of factors, including cost-benefit analyses, epidemiological circumstances, governmental laws, and vaccine availability.

Additionally, the following factors should be taken into account before finalizing the immunization program. Adequate immunity is a requirement for managing infectious pressure on farms, hence it is important to offer appropriate vaccination programs to maintain the flock's or poultry's health state in order to ensure good disease control. Additionally, there is a chance that the flock has an infection that is just subclinical, that additional immunosuppressive infections or diseases caused by field strains may appear soon after the vaccine, or that the infection is a mutant strain. Finally, the number of antigens may have an impact on the administration, management, storage, and quality of the vaccination [18-28].

The use of technologies like reverse genetics, nucleic acid vaccines, subunits, and recombinants in the production of vaccines can slightly lower the cost of vaccinations while guaranteeing maximum or high efficacy and allowing quick and simple intercessions to deal with the microbiota's ongoing mutation. Similar to how improvements in vaccines for bacterial infections could result in less frequent use of antibiotics and, as a result, a decrease in the emergence of bacteria resistant to antibiotics [28]. In poultry breeding, failure to properly immunize animals can result in a significant reduction, particularly for the parental stocks. Because the parental level can directly affect the production of maternal antibodies and the transfer of passive immunity, great attention should be paid to this level. Breeding operations should reassess their biosecurity, vaccination programs, and hygiene in order to benefit from the immune-related insights gained from the COVID-19 pandemic in the absence of immunizations.

Awareness seminars

The successful regulation of any disease depends upon hygiene, vaccination programs, proper farm sanitization, and suitable programs for educating farmers [2]. Besides this markedly public awareness seminars should employ to educate the farmers about the necessary measures to be taken as a safeguard against zoonotic diseases. Programs for poultry farmers that offer continual education and training have been successful thus far. They should pursue professional development and employment since they have updated and improved the knowledge of their owners, employees, and workers. We have learned through COVID-19 that education levels and public awareness are crucial for preventing the spread of zoonosis and controlling its incidence.

These educational initiatives might be summed up as follows:

1. In poultry farming hygiene, biosecurity, disease control, and immunity.
2. Threats from newly emerging diseases and viral diseases.
3. Basic poultry husbandry, welfare, and behavior.
4. Quality, and hygiene of poultry products.
5. The health of poultry farmers, laborers' rights, welfare, and zoonotic disease control and prevention in poultry farms and plants.
6. Update on the recent poultry industry.

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These programs are aimed at farm owners as well as laborers, owners, veterinarians, and agriculturists. In general, it is anticipated that basic scientific background and knowledge of biosecurity and hygienic practices in poultry farming will improve. It is also anticipated that information on hatcheries, processing facilities, cross-reactions, feed mills, and improvements to workplace and environmental safety will be updated and refreshed for the relevant individuals. The industry is positively impacted by these education programs, improved human well-being, and restricted the loss of animals and humans.

Conclusion

In conclusion, the COVID-19 pandemic has highlighted the importance of global cooperation and communication in the poultry industry. To prevent future outbreaks, it is crucial to prioritize biosecurity, hygiene, and disease management strategies on poultry farms and processing facilities. Education programs for poultry farmers and workers should be developed to improve their knowledge and skills in these areas. Increasing research funding and efforts to develop new vaccines and diagnostic technologies is also recommended. Finally, we should prioritize the natural immune system of poultry as the first line of defense against diseases, and provide necessary measures for frontline workers. By implementing these actions, we can ensure the health and safety of poultry, reduce the spread of diseases, and benefit both the industry and consumers.

Recommendations

The article suggests several actions to address the consequences of the COVID-19 outbreak on the poultry sector. These actions include: increasing research funding for developing vaccines and diagnostic technologies, implementing stricter laws and regulations for hygiene standards and zoonotic disease control, developing educational programs for farmers and workers, promoting global cooperation, prioritizing the natural immune system of poultry, and emphasizing the importance of frontline workers. Overall, these actions will improve the health and safety of poultry, reduce the spread of diseases, and benefit both the industry and consumers.

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