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Fowl Adenovirus in Chickens: Diseases, Epidemiology, Impact, and Control Strategies to The Malaysian Poultry Industry – A Review

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ABSTRACT

Fowl adenovirus (FAdV) infection is a major threat in commercial poultry farms which exerts serious economic impacts on the poultry industry. At the end of 2018, it was reported that a decrease of 9.0% in revenue to RM692.9 million was due to high mortality and low broiler production volume as a result of inclusion body hepatitis (IBH) outbreaks in Malaysia. Fowl adenovirus is a double-stranded DNA virus made up of 5 genotypes and 12 serotypes. The potential danger posed by this virus to the Malaysian poultry industry is hereby discussed. Fowl adenovirus serotype 8b has been reported to be predominant in Malaysian chicken where it causes IBH. It predominantly affects 3 to 7 weeks old broiler chickens as well as layer chickens. Inclusion body hepatitis has been reported in farms in the states of Perak, Johore, and Malacca in Malaysia with a mortality range of 9.6-30%. Morbidity is low and infected chickens may present crouching position with ruffled feathers and die within 48 hours or may recover. Recovered chickens usually indicate low feed intake, feed conversion, and weight gain. Typical IBH lesions include friable, and inflamed liver, petechial hemorrhages on the musculature, and microscopic basophilic/eosinophilic inclusion bodies in the hepatocytes. Fowl adenovirus can be transmitted vertically from hen to offspring through the eggs and cause disease conditions to chicks especially those with no or low maternal antibodies. It is also transmitted horizontally through contact with feces and fluids from infected birds or humans as well as contaminated fomites. Although adequate biosecurity measures could reduce the incidences of this infection, some strains are resistant to disinfectants. Therefore, the major form of control is vaccination which makes the development of live attenuated and potent inactivated vaccines imperative. To avoid a crisis in broiler meat production in the country, regional cooperations among major stakeholders in the Malaysian poultry industry are advised to eradicate this disease. Inclusion body hepatitis in Malaysia could cause a significant reduction in broiler meat production and therefore is a potential danger to the Malaysian poultry industry.

Keywords: Broiler chicken, Fowl adenovirus, Inclusion body hepatitis, Serotype 8b, Vaccine

INTRODUCTION

Fowl adenoviruses (FAdVs) has been identified as an etiological agent of inclusion body hepatitis (IBH), hepatitis-hydropericardium syndrome (HHS), gizzard erosion, necrotizing pancreatitis, and respiratory disease in the poultry industry (Nakamura et al., 2002; Singh et al., 2016; Morshed et al., 2017; Norfitriah et al., 2018; Cui et al., 2020; Abd El-Ghany, 2021). The FAdV belongs to the family *Adenoviridae* and is comprised of five molecular species (A to E) (Harrach et al., 2012). Fowl adenovirus is made up of 12 serotypes ascribed FAdV1-7, FAdV8a, FAdV8b, and FAdV9-11 (Hess, 2000; Rahul et al., 2005). Each serotype was then assigned to a specific genotype which they are synonymous with as follows: Type A (FAdV1); Type B (FAdV5); Type C (FAdV4 and FAdV10); Type D (FAdV2, FAdV3, FAdV9, and FAdV11) and Type E (FAdV6, FAdV7, FAdV8a, and FAdV8b) (Kajan et al., 2013; Marek et al., 2013; Schachner et al., 2018).

Malaysia is amongst the top global consumers of poultry meat worldwide with 63kg meat consumption per capita in 2019 (Poultry World, 2020). However, IBH caused by FAdV serotype 8b is a major threat to the poultry industry in recent years with significant economic

losses due to high mortality and poor production in commercial farms (Norina et al., 2016; Sohaimi et al., 2019). At the end of 2018, it was reported that a decrease of 9.0% in revenue to RM692.9 million was due to high mortality and low broiler production volume as a result of inclusion body hepatitis (IBH) outbreaks in Malaysia. Thus, proper biosecurity and vaccination are crucial to sustaining food security in the country. The number of clinical cases of IBH was continued to increase in a recent year due to unavailable local vaccines against high pathogenic FAdV serotype 8b in commercial chickens (Sohaimi et al., 2019; Sabarudin et al., 2021).

In this paper, we aim to highlight the importance of FAdV infections in chickens with the disease impact on the poultry industry. Virus transmission by horizontal and vertical modes necessitates excellent control strategies to overcome the disease outbreak in commercial chicken farms. To enhance farm productivity and performance, disease eradication policies involved multiple levels of authority and implementation of vaccination against FAdV are a major focus of interest as discussed in this paper.

TRANSMISSION OF FAdV

Fowl adenovirus can be transmitted vertically from hens to offspring through the eggs and horizontally from one bird to another through contact with respiratory fluids, feces, and fomites (Pereira et al., 2014). Due to the presence of maternal antibodies, the virus will remain latent in the chick prior to virus excretion in feces at age 2 to 4-week-old. Normally, chicks hatched from infected eggs do not develop the disease however, excretion of the virus could start from day-old. Subsequently, the excreted virus could be a source of infection for the chicks without maternal antibodies (Gupta et al., 2017). Even the chicks with a maternal antibody could develop IBH once the antibodies decline. Adenoviruses are frequently isolated from hens during the period of peak egg production (Gupta et al., 2017). This upsurge in virus activity ensures maximum transmission of the virus to the next generation, through the egg. Among layer chickens, virus excretion is usually at a maximum age of 5 to 9 weeks, but excretion could continue beyond fourteen weeks old. It is possible to isolate different serotypes in one farm (Jordan et al., 2019). The humoral antibody may not prevent excretion, as adult birds have been found to excrete virus despite high levels of neutralizing antibody to the same serotype which also means that humoral antibody may not offer protection against infection with a different serotype (Scachner et al., 2018).

Vertical transmission of FAdV in breeder flocks resulting disease outbreak in progeny chicks with poor hatchability and chick quality as well as high mortality in young chicks up to 80-85% (Junnu et al., 2015; Kiss et al., 2021). In addition, oral ingestion of infected feces in chickens triggers horizontal transmission since a high virus load of FAdV is found in feces (McFerran and Adair, 2003). As a result, serious economic losses in the profitability of commercial premises due to high mortality as well as poor production and performance were noticed in affected flocks (Hair-Bejo, 2005).

Horizontal transfer is one of the most important forms of transmission. This occurs most often by contact between birds and by direct contact with fomites, vehicles, and human beings (Ono et al., 2007; Kataria et al., 2013). The virus is excreted in high titers in the feces and since the virus multiplies in the nasal and tracheal mucosa, conjunctiva, and kidneys, it could be present in other secretions or excretions (Domanska-Blicharz et al., 2011). Moreover, semen could contain the virus and could be a vital source of dissemination especially when artificial insemination is practiced. Chicks excrete a higher amount of FAdV for longer periods than adult chickens (McFerran and Smyth, 2000).

Other forms of transmission have been reported to be associated with FAdV in chicken. Airborne transmission is not usually possible except for short distances, however, spread from contaminated litter to newly introduced chicks is highly possible (McFerran and Smyth, 2000). If adequate control measures are not taken, the infection could spread fast due to the reactivation of latent virus especially in broiler units. FAdV was detected in live Newcastle disease (La Sota strain) and Avian encephalomyelitis (Van Roekel strain) vaccines produced between 1991 and 1994 by the same manufacturer (Barrios et al., 2012).

However, some FAdV strains produce subclinical infections, sometimes due to maternal antibodies (Gupta et al., 2017) or low virulence (McFerran and Smyth, 2000). The presence of latent adenovirus may be the reason why some researchers have often identified FAdV as opportunistic pathogens (Jorgenssen et al., 1995) but realistically some strains have established themselves as pathogenic with possibilities of very high mortality to susceptible flocks.

DISEASES ASSOCIATED WITH FAdV INFECTION

Globally, FAdV infections in chickens have been reported in the poultry industry with a serious impact on young

chickens as they may occur at any age of commercial broiler, breeder, or layer chickens. The severity of the lesions is directly related to the bird's age and the level of maternally derived antibodies (Kiss et al., 2021). In addition, the pathogenicity of the virus strains and immunosuppressive conditions are the other factors that determined the disease outcome in the infected chickens (Saifuddin et al., 1992).

Fowl adenoviruses are incriminated in diseases conditions such as IBH, HHS, and gizzard erosion in chickens with serious economic impact due to high mortality, poor performance, and productivity (Norfitriah et al., 2018; Cui et al., 2020; Cizmecigil et al., 2020). Based on epidemiological findings, serotypes 2, 8a, 8b, and 11 caused IBH, while, serotype 4 was reported as the main causative of HHS which predominated in Pakistan, India, South Korea, and China (Morshed et al., 2017; Scachner et al., 2018; Wajid et al., 2018; Cui et al., 2020; Suohu et al., 2020). FAdV serotype 1 and 8b were reported as the primary agents of gizzard erosion outbreaks in chicken farms (Ono et al., 2003; Schachner et al., 2020).

Inclusion body hepatitis was first reported in Malaysia in 2005 (Hair-Bejo, 2005). Since then, the IBH cases were continued to increase due to unavailable local vaccines to control the disease outbreak (Norina et al., 2016; Mat Isa et al., 2019; Norfitriah et al., 2019; Sabarudin et al., 2021). Based on the molecular findings, only genotype E (serotype 8b) has been reported that causes IBH (Sohaimi et al., 2018). Sudden onset of high mortality is usually seen after 3-4 days of infection and resolved on the fifth day, however, infections were continued sporadically for 2-3 weeks (Hair-Bejo, 2005). Morbidity is low and sick birds adopt a crouching position with ruffled feathers and die within 48 hours or recover. Mortality may reach 10% and occasionally go up to 30%. Surviving birds may present low weight gain and poor growth associated with low feed intake and low feed conversion, tenosynovitis, and respiratory diseases (Adair and Fitzgerald, 2008). Normally, broiler chickens at 3 to 7 weeks of age are infected with IBH, but infection has also been reported in broiler breeders as young as 7-day old and as old as 20 weeks. In layer and breeder pullets, infections occasionally occurred at age of 10 to 20 weeks (Norfitriah et al., 2018; Abghour et al., 2019; Jordan et al., 2019).

Affected birds displayed typical pathologic lesions such as enlarged mottled and friable livers, swollen kidneys (Morshed et al., 2017). Hemorrhages may also be present in the liver and musculature. Histological examination showed numerous eosinophilic intranuclear inclusion bodies and infrequently basophilic inclusion bodies in hepatocytes (Hair-Bejo, 2005). Atrophy of the bursa of Fabricius and thymus was reported, together with aplastic bone marrow (Domanska-Blicharz et al., 2011). In addition, other gross lesions were also seen such as gizzard erosions, necrotizing pancreatitis, and mild proventriculitis with wet unformed feces in chickens infected with adenovirus via the oral route (Lenz et al., 1998).

Hepatitis-Hydropericardium Syndrome (HHS) is an infectious disease occurring in broiler chickens at 3 to 5 weeks of age. It is caused predominantly by FAdV 4 and is characterized by hydropericardium and hepatic necrosis (Abdul-Aziz and al-Attar, 1991). In 1987, a new syndrome affecting chickens named hydropericardium syndrome was observed in Angara Goth, Pakistan from where the name Angara disease has been derived (Asthana et al., 2013; Ye et al., 2016). The disease has subsequently been reported in many countries including Iraq (Abdul-Aziz and al-Attar, 1991), Kuwait, India (Abdul-Aziz and Hassan, 1995; Dahiya et al., 2002), Mexico, Ecuador, Peru, Chile (Toro et al., 1999), USA (Mazaheri et al., 1998), Russia (Lobanov et al., 2000), Japan (Nakamura et al., 1999), and Poland (Niczyporuk, 2016) resulting in heavy economic losses.

In recent years, the frequency of HHS has also been increasing in many countries, such as India (Suohu and Rajkhowa, 2020), Pakistan (Wajid et al., 2018), China (Cui et al., 2020), South Korea (Choi, 2012), Japan (Mase et al., 2012), Hungary (Kajan et al., 2013), Canada (Grgic et al., 2011), Thailand (Songserm, 2007; Witoonsatian et al., 2008) and Poland (Niczyporuk, 2016).

HHS disease differs from IBH only in that the mortality rate and the incidence of HHS are much higher (McFerran and Smyth, 2000). The disease principally affects meat-producing birds between three and six weeks of age, with mortality from 20 % to 80% (Kataria et al., 2013). Hydropericardium syndrome also occurs in breeding and laying flocks, with lower mortality rates (Chen et al., 2019). The disease is characterized by the accumulation of clear fluid (up to 10 ml) in the pericardium. Pulmonary edema, enlarged liver, and pale enlarged kidneys are usually present. In addition, multifocal coagulative necrosis of the liver is observed, with mononuclear cell infiltration and intranuclear basophilic inclusions in the hepatocytes. The serological response to Newcastle disease vaccination is impaired (McFerran and Smyth, 2000). The disease is considered to be the result of infection with adenovirus type 4 or 8 although some workers consider that other factors may be

involved (Shane and Jeffery, 1997; Toro et al., 1999). HHS has caused huge economic losses to the poultry industry due to the high mortality rate and poor productivity (Balamurugan and Kataria, 2004; Zhang et al., 2016).

On the other hand, FAdV-1 from the high virulent strain caused gizzard erosion in broiler and layer chickens as reported in Japan and Germany (Ono et al., 2003; Schade et al., 2013). In some cases, gizzard erosion is also caused by FAdV serotype 8 in broiler chickens (Okuda et al., 2004). Chickens had reduced weight gain and high mortality up to 80% (Schade et al., 2013). The typical gross lesions of gizzard erosion were discoloration and erosion of koilin layer as well as gastric perforation with dilated proventriculus and gizzard in some cases (Lim et al., 2012). Microscopically, necrotic gizzard mucosa with evidence of intranuclear inclusion bodies was detected in the enlarged nuclei of degenerating epithelial cells of the gizzard (Ono et al., 2001). The disease affects the broiler`s flock's performance and influences body weight and condemnation rate at a slaughterhouse (Ono et al., 2001; Ono et al., 2004).

Necrotizing pancreatitis was reported in 19-day-old broiler chickens with pinpoint white foci in the pancreas along with HHS and gizzard erosions (Nakamura et al., 2002). Histologically, multifocal necrosis of acinar cells in pancreatic tissue was observed with detection of FAdV antigen by immunohistochemistry staining (Nakamura et al., 2002).

In addition, respiratory disease is caused by FAdV-1 mainly in cases of quail bronchitis at age of 5 days to 8 weeks (Singh et al., 2016). Gross lesions in the respiratory tract include mucus in the trachea, congested lungs, and caseous air succulitis. Interstitial pneumonia, fibrinoheterophilic rhinitis, heterophilic bronchitis, and tracheitis were recorded under microscopic examination with changes in bronchial respiratory epithelium, such as deciliation, desquamation, and necrosis (Singh et al., 2016).

EPIDEMIOLOGY

The FAdVs expression appears to be ubiquitous in domesticated fowl worldwide and is often isolated from asymptomatic chickens (Wang et al., 2011; Mettifogo et al., 2014). Since the discovery of IBH in the USA (Helmboldt and Frazier, 1963) and subsequently HHS in Pakistan (Abdul-Aziz and Al-Attar, 1991) this syndrome and its various manifestations have been reported in several countries in North and South America, Europe, Asia, and Oceania, (Toro et al., 1999; Ono et al., 2003; Rahul et al., 2005; Gomis et al., 2006; Manarolla et al., 2009; Mase et al., 2009; Alemnesh et al., 2012; Choi et al., 2012) causing considerable economic losses (Ojkic et al., 2008; Dar et al., 2012).

Fowl adenovirus 4 which causes HHS has been present in China prior to 2014 without any major outbreak (Zhang et al., 2016). In 2015, molecular epidemiology findings revealed the substitution of 37 nucleotide bases and as much as 13 amino acid changes in the hexon genes among the isolates. It indicates that these isolates were clustered independently in the phylogenetic tree branch compared to the previous isolates before 2014 and thus, those mutations contribute towards severe HHS outbreak in China (Zhang et al., 2016).

In Korea, FAdV 4, 8b, and 11 were isolated from clinical cases of HHS and IBH from broilers (9-30 days old), layer chickens (23-112 days old), and native chicken (14-65 days old) with cumulative mortality ranging from 0.1-55% (Choi et al., 2012). In Thailand, Songserm (2007) and Witoonsatian et al. (2008) reported cases of IBH caused by FAdV type 2 affecting broilers 3-5 weeks of age. They showed typical IBH lesions with mortality ranging from 5-30%.

Hydropericardium-Hepatitis Syndrome (HHS) disease in India was first noticed during April-July 1994 in some parts of Jammu and Kashmir, Punjab, and Delhi as reported by Gowda and Satyanarayana (1994) and subsequently spread to Uttar Pradesh in November 1994 (Kumar et al., 1997) and throughout the country (Asrani et al., 1997). The trend in Malaysia could follow the same pattern if no drastic measures are taken since the IBH first occurs in Perak in 2005 (Hair-Bejo, 2005) prior distribution to other states involves Johore, Malacca, and Sarawak as reported in 2016 and 2019 (Norina et al., 2016; Sohaimi et al., 2019). The IBH cases were continued to increase in a recent year which necessitates proper plan and control measures in the country. Also in India, a respiratory infection caused by FAdV was reported in 2011 which resulted in eosinophilic intracellular inclusion bodies occurring in the tracheal and laryngeal epithelium of infected chickens (Gowthaman, et al., 2012).

IMPLICATION OF FOWL ADENOVIRUS TOWARD MALAYSIAN POULTRY INDUSTRY

Inclusion bodies hepatitis was first reported in Malaysia in 2005 (Hair-Bejo, 2005). The outbreak occurred on a farm in Perak involving 34-day old broilers chickens. The birds

showed enlarged friable, pale, and fatty liver; complicated chronic respiratory disease, fibrinous perihepatitis, peritonitis, and airsacculitis. Eosinophilic and basophilic inclusion bodies were evident. This outbreak involved 36,700 broiler chickens aged 34 days old from which 3542 (9.65%) died. Recently, FAdV serotype 8b was confirmed as a primary cause of IBH and caused 100% mortality in specific pathogen-free chickens at the fourth day post-inoculation (Norfitriah et al., 2019). The chickens showed clinical signs of depression, weakness, prostration, diarrhea, and ruffled feathers within 12 to 24 hours prior to death.

In 2015, IBH was reported in Malacca and Johore involving FAdV group E serotype 8b (Norina et al., 2016). The birds showed clinical signs of lethargy, ruffled feathers, and inappetence. Upon necropsy, pale yellow friable enlarged liver with multiple petechial hemorrhages, hydropericardium, and gizzard erosion was recorded in affected chickens (Norina et al., 2016; Norfitriah et al., 2018). The kidney was also congested and enlarged. Moreover, 9000 out of 30,000 (30%), 12 day-old broiler chicks showed mortalities.

FAdV-8b in Malaysia caused concurrent IBH and gizzard erosion in 27-week-old commercial layer chickens with a decline in eggs production and 2% total mortality in the state of Sarawak (Norfitriah et al., 2018; Sohaimi et al., 2018). Ulceration, erosion, and hemorrhages of koilin layer in the gizzard were noticed in dead chickens. Isolation into SPF chicken embryonated eggs produced numerous basophilic intranuclear inclusion bodies in hepatocytes (Norfitriah et al., 2018). In a recent year, an IBH case was reported in Sabah state, next to the Sarawak region causing 2% mortality in broiler chicken farms (Ahmed et al., 2021).

Inclusion body hepatitis is already a serious threat to Malaysia's poultry industry, as seen by the first outbreak in the north at the state of Perak and the second in the south which involved Johore and Malacca states (Hair-Bejo, 2005; Norina et al., 2016). Currently, the disease is distributed to the east part of Malaysia in the state of Sarawak and Sabah (Norfitriah et al., 2019; Ahmed et al., 2021). It is obvious that the Malaysian poultry industry faces a major crisis which could bring untold hardship to farmers and the country in case the disease is not handled with concerted attention. Unreported cases of IBH have occurred in other regions of Malaysia, mainly in the southern part of Peninsular areas in the commercial broiler premises. Sudden peak mortality with abnormal gross findings in the livers and gizzard were observed in dead chickens due to FAdV infection.

Although FAdV serotype 4 that induces mortalities up to 75% has not been reported in Malaysia, there is an obvious reason for concern and worry. Chicken is a very important part of Malaysian cuisine enjoyed by every culture and religion. It is the cheapest source of protein for the average Malaysian and is also devoured by most foreigners. Malaysia has approximately 2606 broiler grower farms which produced 767 million chickens in 2017, out of which about 52.71 million birds and 15.01 thousand tons of chicken meat were exported (Bahri et al., 2019). This is a huge market that contributes enormously to the gross domestic product and is a good foreign exchange earner which should not be allowed to enter into crisis. It is pertinent for stakeholders to employ all necessary measures to safeguard this very important industry from crisis. This makes ascertaining the status of FAdV from various states imperative and should be carried out as a matter of urgency and information made available to all stakeholders.

CONTROL AND PREVENTION STRATEGIES

FAdV is widespread among many species of birds and could transmit from domestic birds to wild birds (McFerran and Smyth, 2000). The widespread distribution of the disease throughout the world means that eradication would be very difficult or impossible. In fact, FAdV is resistant to disinfectants (ether and chloroform) and high temperature making disinfection of poultry houses ineffective (Hafez, 2011). Since FAdV is also transmitted vertically, eradication would involve complex measures to exclude infection from breeders and parent stocks but could be the only avenue to prevent infection of progenies.

The movement of birds or eggs from flocks infected with high virulent HHS or IBH viruses to uninfected areas should be discouraged in broilers production due to the potential source of horizontal transmission. Currently, no trade restrictions exist for infections with conventional adenoviruses, therefore testing for these infections is usually not taken seriously. The best option, however, is to certify that birds are free from any strain of FAdV prior imported into the country by an appropriate screening test for detection of the viral agent.

Despite all these circumstances, good sanitary measures and prevention of immunosuppression would highly reduce the incidences of FAdV infections (Abdul-Aziz and Al-Attar, 1991). Adequate measures such as sanitation and proper biosecurity should be implemented to prevent FAdV infection of breeders and subsequently prevent infection of the offspring (McFerran and Smyth,

2000). Like other viral diseases, prevention of IBH and HHS through vaccination would be more realistic. This could be achieved through vaccination of the breeders to prevent vertical transmission or vaccination of progenies to prevent horizontal transfer (Toro et al., 2002).

Regional cooperation is the best option for the FAdV control among Malaysia and Southeast Asian countries such as Thailand and Indonesia as well as other unreported countries such as Singapore, Philippines, Brunei, Vietnam, Cambodia, Myanmar, Laos, and Timor-Leste. Therefore, to effectively control FAdV in Malaysia, there is a need for cooperation with other countries within and outside the region. Regional integration and cooperation are usually the best approaches for the effective eradication of any disease. There is a need for some kind of regional coordination unit, that is staffed to provide the management, technical and administrative skills. This can be achieved through several ways establishment of a body with a member country as the host, operating under a regional organization such as SEAFMD, or operating under an existing Regional Commission of an international organization like FAO, OIE, or One Health Initiative.

In any of these cases, there is a need for an organization or commission that can establish an accountable fund and employ and manage staff. Apart from management of human and material resources provided, the function of the body includes working with Departments of Veterinary Services and Ministries of Agriculture of member countries and other stakeholders to harmonize national plans for FAdV control, where they exist, and come up with an integrated framework for the control of the disease in the region. Moreover, it is important to control the movement of poultry and its products to and from the region and within the region. The government should get member countries to show commitment in following internationally acceptable best practices in the control of the disease. In addition, is it best to develop and implement a communication and public awareness program to complement and strengthen member country activities as well as establishing and maintaining a regional website with the links and functions. The authorities should periodically hold conferences and workshops to enable the exchange of information and experiences among the members other including regional meetings rotated within the member countries. It is possible to carry out epidemiological surveys in collaboration with faculties of veterinary medicine and the private sector in member countries and establish a regional surveillance database. Furthermore, collaboration among the local universities, research institutes, and poultry industry may encourage research works especially targeting diagnosis and vaccine development against the disease. The works may be extended globally by establishing collaboration with relevant organizations and other international donor agencies. It is essential to publish reports periodically on the status and achievements made.

VACCINES AND VACCINATION

In the previous work, the development of FAdV vaccines has not been the researcher's priority because of the absence of important diseases caused by adenoviruses (McFerran and Smyth, 2000), rather emphasis had been on the development of adenoviral vectors for vaccines against other diseases. There is limited availability of commercial vaccines to control FAdV infections. However, with the outbreaks of IBH and HHS in various countries, the development of autogenous vaccines has been attempted with varying success. An inactivated oil-emulsion FAdV vaccine is reported to be highly effective against IBH and HHS (Kim et al., 2014; Junnu et al., 2015; Du et al., 2017). Recently, vaccination was practiced in several countries to reduce the losses by application of either live or inactivated vaccine, subunit vaccine, virus-like particles, commercial and autogenous products (Mansoor et al., 2011; Junnu et al., 2015; Hess, 2017; Schachner et al., 2018). In Malaysia, efforts are being made to develop the FAdV vaccine with varying successes (Sohaimi et al., 2019; Ugwu et al., 2020; Sohaimi et al., 2021), and encouragement is required. It seems that the application of vaccines in other countries can control virus spreading at vertical and horizontal levels (Alvarado et al., 2007).

CONCLUSION

Fowl adenovirus is an emerging pathogen that causes IBH, HHS, gizzard erosion, necrotizing pancreatitis, and respiratory diseases in chickens worldwide. Fowl adenovirus particularly serotypes 8b has been identified in Malaysia where it causes IBH with mortality reported to be ranging from 9.6% - 30% among mainly broiler chickens aged 3-7 weeks. It is transmitted vertically from hen to chick and horizontally through contact with infected chicken or mechanically through contaminated fomites. Being an emerging infection in Malaysia, its devastating effects could be arrested in time if adequate measures are employed. FAdV consequently can be described as a potential danger to the Malaysian poultry industry especially the broiler production lines and should require effective control strategies.

DECLARATIONS

Competing interests

The authors have declared that no competing interest exists.

Ethical considerations

Plagiarism, consent to publish, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy have been checked by the authors.

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