FEED- BASED INFECTIOUS BURSAL DISEASE VACCINATION IN VILLAGE CHICKEN

MUHAMAD SYAFIQ AIMAN BIN ALIAS

FP 2019 8

FEED- BASED INFECTIOUS BURSAL DISEASE VACCINATION IN VILLAGE CHICKEN

By

MUHAMAD SYAFIQ AIMAN BIN ALIAS

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

October 2018

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

FEED-BASED INFECTIOUS BURSAL DISEASE VACCINATION IN VILLAGE CHICKEN

By

MUHAMAD SYAFIQ AIMAN BIN ALIAS

October 2018

Chair : Azhar bin Kasim, PhD
Faculty : Agriculture

Infectious bursal disease (IBD), also known as Gumboro disease, is an acute, highly contagious viral infection in chickens that can be exhibited by inflammation and followed by the atrophy of the bursa of Fabricius and immunosuppression. Clinically the disease can be seen only in chickens older than 3 weeks. Vaccination represents a very useful method for IBD controlling. The timing of optimal vaccination, doses used and the administration routes represent the most important factors in controlling the disease. In addition, the immunogenicity and histopathology of chickens can be used to monitor IBD in flocks. However, the studies between certain breed of chicken such as village chicken and IBD vaccine is lacking. The current research present an overview of immunogenicity and histopathology of UPM-bred village chickens vaccinated with IBD vaccine via feed. It was the objective of this study to evaluate and determine the most effective route for IBD vaccination on UPM-bred village chicken.

In the experiment, one hundred and five day-old UPM-bred village chicks were reared in experimental house. The chicks were randomly divided into 3 groups which were; group A (feed based IBD vaccination), group B (IBD vaccination via intraocular route), and group C (control). The chickens in group A and B were vaccinated at day 14 with the IBD vaccine, administered according to the manufacturer's recommendations via feed and intraocular routes (0.1ml/chick). Five chicks in the control group were sacrificed at 1, 7, 14, 21, 28, 35 and 42 days of age. Five chickens each from the groups A and B were sacrificed at 21, 28, 35 and 42 days of age. Body weights were taken and serum samples were collected for IBD antibody detection using enzyme linked immunosorbent assays (ELISA) prior to necropsy. On necropsy, the gross lesions were recorded and the bursa of Fabricius was weighed and fixed in 10% buffered formalin for histopathological examination. The study proved that attenuated live strain IBD vaccine is safe and effective to be used. There were no clinical

signs of IBD recorded throughout the trial in all groups of chickens. There were no significant ($p>0.05$) differences in body weight between the 3 groups. The bursa weight of the chickens in groups A and B were insignificantly ($p>0.05$) different but were significantly ($p<0.05$) lower than the control group at day 21 and above. At the end of the study, it is confirmed that feed based vaccination can induce the protective level of IBD antibody as high as the intraocular route. In addition, feed based IBD vaccination does not affect the weight of the village chickens significantly compared to the intraocular route vaccination.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

VAKSINASI PENYAKIT BURSA BERJANGKIT MELALUI MAKANAN PADA AYAM KAMPUNG

Oleh

MUHAMAD SYAFIQ AIMAN BIN ALIAS

Oktober 2018

Pengerusi : Azhar bin Kasim, PhD
Fakulti : Pertanian

Penyakit Bursa Berjangkit (PBB), juga dikenali sebagai penyakit Gumboro, adalah jangkitan virus pada ayam yang boleh dilihat pada keradangan dan diikuti oleh atrofi pada bursa Fabricius dan imunosupresi. Secara klinikal, penyakit ini hanya boleh dilihat pada ayam yang lebih tua daripada 3 minggu. Vaksinasi merupakan kaedah yang sangat berguna dalam mengawal PBB. Masa vaksin yang optimum, dos yang digunakan dan kaedah vaksinasi merupakan faktor yang paling penting dalam mengawal penyakit ini. Di samping itu, imunogenik dan histopatologi ayam boleh digunakan untuk memantau PBB dalam kawanan. Walau bagaimanapun, kajian antara baka ayam tertentu seperti ayam kampung dan vaksin IBD adalah kurang. Penyelidikan semasa membentangkan gambaran keseluruhan imunogenik dan histopatologi ayam kampong baka-UPM dengan vaksin IBD melalui makanan. Objektif kajian ini adalah untuk menilai dan menentukan kaedah yang paling berkesan dalam vaksinasi IBD pada ayam kampung baka-UPM.

Dalam eksperimen ini, seratus lima anak ayam kampung baka-UPM yang berusia satu hari dibela di rumah eksperimen. Anak ayam dibahagikan secara rawak kepada 3 kumpulan iaitu; kumpulan A (vaksin PBB berasaskan makanan), kumpulan B (vaksin PBB melalui kaedah intraokular), dan kumpulan C (kawalan). Ayam-ayam dalam kumpulan A dan B telah divaksin pada hari ke 14 dengan vaksin PBB, melalui makanan, yang diberikan mengikut cadangan pengeluar melalui kaedah makanan dan intraokular (0.1ml/anak ayam). Lima ekor ayam dalam kumpulan kawalan telah disembelih pada umur 1, 7, 14, 21, 28, 35 dan 42 hari. Lima ayam masing-masing dari kumpulan A dan B dikorbankan pada umur 21, 28, 35 dan 42 hari. Berat badan ayam diambil dan sampel serum dikumpulkan untuk pengesanan antibodi PBB menggunakan ujian imunoserapan enzim yang berkaitan (ELISA) sebelum nekropsi dilakukan. Semasa nekropsi, lesi kasar direkodkan dan bursa Fabricius ditimbang dan diletakkan ke dalam formalin tertampan 10% untuk pemeriksaan

histopatologi. Kajian itu membuktikan bahawa vaksin PBB strain hidup yang dilemahkan adalah selamat dan berkesan untuk digunakan. Tiada tanda-tanda klinikal PBB direkodkan sepanjang eksperimen di semua kumpulan ayam. Tiada perbezaan ($p>0.05$) yang signifikan dalam berat badan ayam antara 3 kumpulan. Berat bursa ayam dalam kumpulan A dan B tidak banyak ($p> 0.05$) berbeza tetapi ketara ($p <0.05$) lebih rendah daripada kumpulan kawalan pada hari ke 21 dan ke atas. Pada akhir kajian, ia disahkan bahawa vaksinasi berasaskan makanan boleh menyebabkan tahap perlindungan antibodi PBB setinggi vaksinasi kaedah intraokular. Di samping itu, vaksin PBB berasaskan makanan tidak memberikan kesan kepada berat ayam kampung dengan ketara jika dibandingkan dengan vaksinasi kaedah intraokular.

ACKNOWLEDGEMENTS

First of all, I want to thank Allah (S.W.T) to whom all adoration and praises are due for the successful completion of this work.

My greatest gratitude goes to my supervisor, Chairman of my supervisory Committee, Dr Azhar Kasim for his patience, understanding, guidance and encouragement throughout the duration of this work regardless of the obstacles and problems faced along the journey. I wish to extend my special gratitude to my co-supervisor Professor Dr Mohd Hair-Bejo and my former supervisor Dr Anjas Asmara @ Ab Hadi Samsudin for their support, suggestion, good advice and criticism, may God reward you abundantly.

My sincere appreciation to the Animal Science Head of Department Professor Loh Teck Chwen and Dean, Faculty of Agriculture, Professor Abdul Shukor bin Juraimi of Universiti Putra Malaysia for allowing me to use the facilities in the faculty. I would also like to thank all the staff of Animal Science Department and Veterinary especially Associate Professor Dr. Halimatun Yaakub, Professor Dr Jothi Malar Panandam, Mrs Rohaida Abdul Rashid, Mrs Kamariah Jamhari, Mr Saparin Demin, Mr Khairul Anwar Bahari, Mrs Nurul Shuhadah Adnan, Mrs Norhayati Sahat and Mrs Latifah Mohd Hanan. Thank you very much for your assistance.

My special thanks to my friends Mrs Nurdiyana 'Aqilah Roslan, Ms. Atiqah Abdul Hamid, Mrs. Liyana Harun, Mr. Nizam Hayat, Mr. Mohamad Zaihan Zailan, Mr. Muideen Adewale, Mr. Mohammed Al-Qazzaz, Mr. Ali Zubaidy, Mr. Jurhamid Imlan and Mr. Wan Ahmad Izuddin Wan Ibrahim for their relentless support and encouragement. Indeed, you are all friends in need Mr. Khairul Syafiq Azahar, Mr Azam Azman, Mr Khairulnizam Kamarudin, Mr. Mohd Faizal Yeob Baharuddin and Mr. Hidayat Ali Aman Ali of Farm 2, Department of Animal Science, Faculty of Agriculture, Universiti Putra Malaysia for their assistance during the fieldwork.

I would like to express my profound gratitude and sincere appreciation to my parents (Alias Hashim and Rahimah Bachik) for their financial care, sincere prayers, moral support, encouragement and everything throughout my study period. May Allah in His Infinite Mercy bestow you long life in good health and happiness. You are indeed my precious part in this journey. In addition, my appreciation goes to my siblings (Izza, Aqilah, Lina, Nadrah) for their persistence patience, prayers and encouragement. I am grateful for your awesome love and concern.

Lastly, special thanks to all those who have contributed to the success of this research directly or indirectly. The Almighty God bless you and your family.

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

Azhar bin Kasim, PhD
Associate Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Chairman)

Mohd Hair Bejo, PhD
Professor
Faculty of Veterinary Medicine
Universiti Putra Malaysia
(Member)

_____
ROBIAH BINTI YUNUS, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

Declaration by graduate student

I hereby confirm that:

- this thesis is my original work;
- quotations, illustrations and citations have been duly referenced;
- this thesis has not been submitted previously or concurrently for any other degree at any other institutions;
- intellectual property from the thesis and copyright of thesis are fully-owned by Universiti Putra Malaysia, as according to the Universiti Putra Malaysia (Research) Rules 2012;
- written permission must be obtained from supervisor and the office of Deputy Vice-Chancellor (Research and Innovation) before thesis is published (in the form of written, printed or in electronic form) including books, journals, modules, proceedings, popular writings, seminar papers, manuscripts, posters, reports, lecture notes, learning modules or any other materials as stated in the Universiti Putra Malaysia (Research) Rules 2012;
- there is no plagiarism or data falsification/fabrication in the thesis, and scholarly integrity is upheld as according to the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) and the Universiti Putra Malaysia (Research) Rules 2012. The thesis has undergone plagiarism detection software.

Signature: _____ Date: _____

Name and Matric No.: Muhamad Syafiq Aiman bin Alias (GS42184)

Declaration by Members of Supervisory Committee

This is to confirm that:

- the research conducted and the writing of this thesis was under our supervision;
- supervision responsibilities as stated in the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) are adhered to.

Signature: _____
Name of Chairman of Supervisory Committee: Assoc. Prof. Dr. Azhar Kasim

Signature: _____
Name of Member of Supervisory Committee: Professor Dr. Mohd Hair Bejo

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATE

LIST OF ABBREVIATIONS

%	Percent
ANOVA	Analysis of variance
DOSM	Department of Statistics Malaysia
EID	Egg infectious dose
ELISA	enzyme-linked immunosorbent assayEnzyme Linked Immunosorbent Assay
EU	European Union
FAO	Food and Agriculture Organisation
G	Gauge
H&E	Hematoxylin and Eosin
IB	Infectious bronchitis
IBD	Infectious bursal disease
IBDV	Infectious bursal disease virus
MD	Marek's disease
MDA	Maternal derived antibodies
MOA	Ministry of Agriculture
MVP	Malaysian Vaccine and Pharmaceutical
nm	Nanometre
m^2	Metre square
ND	Newcastle disease
ºC	Degree celcius
PBB	*Penyakit Bursa Berjangkit*
PBS	Phosphate-buffered saline
Ppm	Part per million

PSA	Poultry Science Association
RNA	Ribonucleic acid
S	Second
SAS	Statistical Analysis System
SPF	Specific pathogen-free
STC	Standard challenge
UK	United Kingdom
UPM	Universiti Putra Malaysia
US	United States
USDA	United States Department of Agriculture
vIBD	Virulent infectious bursal disease virus
vv	Very virulent
vvIBDV	Very virulent infectious bursal disease virus
µg	microgram
µl	microliter
µm	Micrometre

CHAPTER 1

GENERAL INTRODUCTION

Human population increasing at a linear progression simultaneously with rapid economy growth with effect of urban transformation, increase income and changes in consumer preference have encouraged the increment in animal protein demand (Devendra, 2006). It is estimated more than 50 billion chickens are raised per annum as a source of food, for their meat and eggs. Other than that, in the United States (US), where the world largest economic activities take place is not left out of the drastic increase in the demand for animal protein source. Each year in the US, more than 8 billion chickens are slaughtered annually to compliment the demand for the meat. In the last three decade, Malaysia has experienced a tremendous increase in demand for animal based protein source too, due to increases per capital consumption of the major meat type (Bisant, 2006).

In Malaysia where chicken is the cheapest source of protein available. It is estimated 46.6kg of poultry meat consumption per capita as reported by Department of Statistics Malaysia (DOSM) in 2015. The low feed conversion ratio of chicken compared to other sources of protein such as beef cattle, sheep and goat is one of the contributing factors. Most of the meat producing poultry are fast growing white plumage broiler chicken raised in modern highly mechanised farms operated by big cooperation. While for rural homes, rearing of *ayam kampung* or village chicken is a tradition. They are known for their hardiness and resistant to diseases compared to the commercial broiler chicken. These chickens provide important source of meat and eggs. Village chickens are usually reared free ranging thus producing more lean muscles and less fat. With the increases of demand on village chicken in Malaysia due to the awareness of its health benefit, it is expected that its production will scale up in the coming years.

Through selective breeding on the Malaysian village chicken, a few village chicken phenotypes were developed at the University of Putra Malaysia (UPM) known as UPM-bred village chicken. It grows faster, can lay 120 to 200 eggs per annum and reach market weight earlier (less than 13 weeks) and more resistant to diseases (Jawad *et al.*, 2015).

Just like any practices, village chicken farming also need protection from diseases to prevent massive loss for the farmers. Therefore, disease prevention is necessary and vaccination is one of the important step taken to prevent diseases to spread among flocks. Vaccines that regularly used in chickens are Marek's Disease (MD), Newcastle Disease (ND), Infectious Bronchitis (IB), and Infectious Bursal Disease (IBD). Until now, IBD has become one of the main enemy for production in the poultry sector worldwide. IBD lead to major production damages causing from great mortality, impaired

growth, excessive carcass condemnation and intense immunosuppression leading to increase vulnerability to other pathogens and interfere with the efficiency of vaccination against other highly virulent diseases. IBD or also known as Gumboro disease is an acute infectious viral infection in chickens displayed by inflammation, followed by atrophy of the bursa of Fabricius, and immunosuppression. Clinically the infection is seen only in chickens older than 3 weeks. The feathers around the vent are usually tainted with faeces comprising plenty of urates. IBD is caused by Birnavirus, a double stranded RNA virus that has a bi-segmented genome and belongs to the genus Avibirnavirus of family Birnaviridae. The virus is about 50 to 55nm in diameter with a single shell. IBD virus (IBDV) is very stable to chemical and physical agents and it can remain for long in a contaminated environment.

In Malaysia, outbreak of IBD due to very virulent IBDV (vvIBDV) was first reported in 1991 (Hair-Bejo, 1993; Phong *et al.*, 2003). Since then, the disease spread throughout the country haunting the vaccinated and non-vaccinated chickens. There are variety of vaccines available in the market that can be found in Malaysia. They are subjectively classified into the "mild", "intermediate" and "hot" strains of attenuated live IBD vaccines based on their pathogenicity and immunogenicity. "Mild" vaccines are low in their invasiveness of the bursa of Fabricius and may easily be neutralized by high maternally derived antibody (MDA) (Hair-Bejo *et al.*, 2014). "Intermediate" and "hot" vaccines are high in invasiveness even with the presence of MDA (Haffer, 1982). The standard and ideal criteria for safety and potency of attenuated live IBD vaccine have been suggested previously (Thorton and Pattison, 1975). Normally, there would be no clinical effects caused by the vaccine when administered at day old and deliberate protection within 10 days of vaccination. The vaccine also usually cause no more than slight and brief reduction in the bursa to body weight ratio with partial and temporary lymphocytes depletion in the bursa with no significant immunosuppression effects.

Usually, intraocular and oral routes via drinking water are the common routes for IBD vaccination in village chickens. Subcutaneous or vent-drop administration was also been reported to be effective against IBDV challenged (Winterfield and Thacker, 1978). The effectiveness of in-ovo vaccination in 18-day-old chicken eggs with embryos, at time the eggs are routinely transferred to hatching tray, was also reported previously (Hair-Bejo *et al.*, 2000). In-ovo vaccination can eliminate the need for post hatch vaccination that is stressful to the chicks. In free-range chickens, feed based vaccine is believed to be the best route of vaccination. Food pellet Newcastle disease vaccine was successfully developed previously (Aini, 1989). However, the safety and immunogenicity of the IBD vaccine for UPM-bred village chicken through feed is unknown. The characteristic of IBDV which is non envelope virus, very stable to chemical and physical agents and can remain for long in environment are of advantages when used as feed based vaccine.

Smallholder farmers with lack of resources are the one whom usually rearing village chicken in small quantity. Vaccination programme forces these farmers

to invest money in terms of labour that also consumes a lot of time. For feed based vaccination, farmers only need to mix the vaccine and feed together and give it to the chickens. In free-range chickens, feed based vaccine is believed to be the best route of vaccination. It is because lack of resources are needed with little effort compared to intraocular vaccination route which required more workers to drop the vaccine into the eyes of chickens, one by one. Thus, feed based vaccination can be of choice and more practical when compared to other conventional routes of vaccination for IBD in the control prevention Of IBDV infection in free-range chickens such as in village chickens. This is strengthen by the proof that feed pellet Newcastle disease vaccine was successfully developed previously (Aini, 1989). With the feed based IBD vaccination on village chicken study, it is hope that farmers can start replacing the conventional route of vaccination thus thriving for a better productivity.

1.1 Objectives

I. To evaluate and determine the most effective route for IBD vaccination on UPM-bred village chicken.

II. To compare two different routes of IBD vaccination.

III. To determine the growth responses of commercial IBD vaccine given to UPM-bred village chicken via feed.

IV. To evaluate the histological changes of IBD vaccinated UPM-bred village chicken.

V. To study the effectiveness of vaccination through antibody titer of IBD vaccinated UPM-bred village chicken flocks using Enzyme Linked Immunosorbent (ELISA) test.

1.2 Hypothesis

Feed based IBD vaccination at 14-day-old UPM-bred village chickens using attenuated live IBD vaccine can successfully induce protective level of IBD antibody similarly to intraocular IBD vaccination.

REFERENCES

Aini I. (1989). Vaccination of village chickens against Newcastle disease. Thesis, University Putra Malaysia, Malaysia.

Aini I. (1990). Field trials of a food-based vaccine to protect village chickens against Newcastle disease. Thesis, University Putra Malaysia, Malaysia.

Alemu Yami, Tadelle D, Million T. and Peters K. J. (2003). Village chicken production systems in Ethiopia: Use patterns and performance valuation and chicken products and socioeconomic function of chicken. Livestock Research Center, Deber Zeit, Ethiopia. Livestock Feed Resource within Integrated Farming Systems 377.

Asif, Manija & Lowenthal, John & E Ford, Mark & Schat, Karel & G Kimpton, Wayne & G.D. Bean, Andrew. (2007). Interleukin-6 Expression after Infectious Bronchitis Virus Infection in Chickens. Viral immunology. 20. 479-86.

Azad A. A., Barrett S. A., Fahey K. J. (1985) The characterization and molecular cloning of the double-stranded RNA genome of an Australian strain of infectiouous bursal disease virus. Virology 143: 35–44.

Azahan E. (2011). The red and black-red native chickens of Malaysia. Proceedings of the 16th Annual Conference Malaysian Society of Animal Production, Volume 4, 21-28.

Benbrook, C. M., & Baker, B. P. (2014). Perspective on dietary risk assessment of pesticide residues in organic food. Sustainability (Switzerland), 6, 3552–3570.

Bisant, K. (2006). Asymmetric price transmission and market integration in the broiler industry in Peninsular Malaysia (Unpublished PhD thesis). Universiti Putra Malaysia, Selangor, Malaysia.

Bolis D. A., H.L. Robinson, L.A. Hunt, R.G. Webster. (2003). Protection against a lethal influenza virus challenge by immunization with a haemagglutinin-expressing plasmid DNA. Vaccine, 11. 957-960.

Bolis D. A. (2002). Market analysis for organic chickens. Dissertation (Master degree in Business Administration) - University of Western Santa Catarina, Joaçaba, Brazil.

Briggs D. J., Whitfill C. E., Skeeles J. K., Story J. D., Reed K. D. (1986). Application of the positive/negative ratio method of analysis to quantitate antibody responses to infectious bursal disease virus using a commercially available ELISA, Avian, 30, 216-218.

Castellini, C., C. Mugnai, and A. Dal Bosco. (2002). Effect of organic production system on broiler carcass and meat quality. Meat Science. 60:219–225.

Cazaban, C., V. Palya, and Y. Gardin. (2015). What a normal bursa of Fabricius should look like in the current chicken lines? Acta Veterinaria Hungarica, 11:438-445.

Cheroutre, H. Cheroutre, F. Lambolez, D. Mucida. (2011). Nature Reviews Immunology, 11, 445-456.

Constance, D. H., & Choi, J. Y. (2010). Overcoming the barriers to organic adoption in the United States: A look at pragmatic conventional producers in Texas. Sustainability. 2(1), 163–188.

Cumming R. B., Spradbrow P. B. (1999). Village chicken production: problems and potential. (editor) proceedings of an international workshop on Newcastle disease in village chickens, control with thermo stable oral vaccines. Kuala Lumpur, Malaysia. 21-24.

Davelaar, F. G. and B. Kouwenhoven, (2007). Some aspects of immunity to infectious bronchitis. Symposium on infectious bronchitis. 23, 48-49.

Delgado, C., M. Rosegrant, H. Steinfeld, S. Ehui, and C. Courbois. (1999). Livestock to 2020: The next food revolution. Food, Agriculture, and the Environment Discussion Paper 28. Washington, DC: International Food Policy Research Institute.

Devendra, C. (2006). Enhancing animal protein supplies in Malaysia: Opportunities and challenges. Kuala Lumpur: Academy of Sciences Malaysia.

Dominika Średnicka-Tober, Marcin Barański, Chris Seal, Roy Sanderson and Carlo Leifert. (2016). Composition differences between organic and conventional meat: A systematicliterature review and meta-analysis. British Journal of Nutrition, 15-16.

Eterradossi N., Saif Y. M. Infectious bursal disease. In: Saif Y.M., Fadly A.M., Glisson J.R., McDougald L. R., Nolan L. K., Swayne D. E. (2008). Diseases of Poultry 12th edition. 185–208.

Fanatico, A. (2006). Alternative poultry production systems and outdoor access. NCAT Agriculture Specialist ATTRA Publications (24).

Fanatico, A. C., Pillai, P. B., Emmert, J. L., Owens, C. M. (2007). Meat quality of slow and fast-growing chicken genotypes fed low-nutrient or standard diets and raised indoors or with outdoor access. Poultry Science, 86, 2245–2255.

Fang X. L., Zhu X. T., Chen S. F., Zhang Z. Q., Zeng Q. J., Deng L., Peng J. L., Yu J. J., Wang L. N., Wang S. B., Gao P., Jiang Q. Y., Shu G.. (2014). Differential gene expression pattern in hypothalamus of chickens during fasting-induced metabolic reprogramming: functions of glucose and lipid metabolism in the feed intake of chickens. National Center for Biotechnology Information: Poultry Science. 93(11):2841-54.

Garnett, T. (2009). Livestock-related greenhouse gas emissions: impacts and options for policy makers. Environmental Science & Policy, 12(4), 491 503.

Geerligs H. J., Ons E., Boelm G. J., Vancraeynest D. (2015). Efficacy, Safety, and Interactions of a Live Infectious Bursal Disease Virus Vaccine for Chickens Based on Strain IBD V877. Avian Diseases. 59(1):114-21.

Glick, B. (1956). Normal growth of the bursa of Fabricius in chickens. Poultry Science. 35:843–851.

H. Block, K. Meyer Block, D. E. Rebeski, H. Scharr, S.de Wit, K. Rohn and S. Rautenschlein. (2007). A field study on the significance of vaccination against infectious bursal disease virus (IBDV) at the optimal time point in broiler flocks positive for maternally derived IBDV antibodies. Avian Pathology, 36(5), 401-409.

Haas, G., Wetterich, F., & Köpke, U. (2001). Comparing intensive, extensified and organic grassland farming in southern Germany by process

life cycle assessment. Agriculture, Ecosystems and Environment, 83, 43–53.
Haffer, K. (1982). Field test studies of the 2512 strain of infectious bursal disease. Avian Diseases, 26:847-851.
Hair-Bejo M., Ng M. K., Ng H. Y. (2004). Day old vaccination against infectious bursal disease in Broiler chickens. Asian Network for Scientific Information, International Journal of Poultry Science. 3: 124-128.
Hair-Bejo M., Liew P. S., Nurulfiza M. I., Omar A. R., Aini I. (2001). Vaccines and vaccination against infectious bursal disease of chickens: prospects and challenges. Pertanika Journal of Scholarly Research Reviews. 2(2): 23-39.
Hair-Bejo, M. (1993). Infectious bursal disease in broilers: pathological changes and virus detection. Jurnal Veterinar Malaysia, 5 (1):49-51.
Hair-Bejo, M., S. Salina, H. Hafiza, S. Julaida. (2000). in Ovo vaccination against infectious bursal disease in broiler chickens. Journal Veterinary Malaysia, 12: 63 -69.
Hair-Bejo, M., 1992. An outbreak of infectious bursal disease in broilers. Jurnal Veterinar Malaysia, 4:168.
Henle, K., Alard, D., Clitherow, J., Cobb, P., Firbank, L., Kull, T.Young, J. (2008). Identifying and managing the conflicts between agriculture and biodiversity conservation in Europe–A review. Agriculture, Ecosystems & Environment, 124(1-2), 60–71.
Ismail N. M. & Saif, Y. M. (1991) . Immunogenicity of infectious bursal disease viruses in Chickens. Avian Dis. 35, 460-9.
Jawad, H. S., L. H. B. Idris, M. B. Bakar, and A. B. Kassim. (2015). Anatomical changes of Akar Putra chicken digestive system after partial ablation of uropygial gland. American Journal of Animal and Veterinary Sciences.
Jawad, H. S., L. H. B. Idris, M. B. Bakar, and A. B. Kassim. (2016). Partial ablation of uropygial gland effect on carcass characteristics of Akar Putra chicken. American Journal of Animal and Veterinary Sciences.
Kitalyi. (1998). Village chicken production systems in rural Africa: household security and gender issues. Food and Agriculture Organization, Animal production and health paper 142, Rome, Italy.
Kitalyi A. J. (1996). Socio-economic aspects of village chicken production in Africa: the role of women, children and non-governmental organizations. Paper presented at the World Poultry Congress, 2 to 5 September 1996, New Delhi, India.
Lal, R. (2004). Agricultural activities and the global carbon cycle. Nutrient Cycling in Agroecosystems, 70(2), 103–116. doi:10.1023/B:FRES.0000048480.24274.0f
Lasher, H.N. & Shane, S.M. (1994). Infectious bursal disease. World's Poultry Science Journal, 50, 133-166.
Leinonen, I., Williams, a G., Wiseman, J., Guy, J., & Kyriazakis, I. (2012). Predicting the environmental impacts of chicken systems in the United Kingdom through a life cycle assessment: broiler production systems. Poultry Science, 91(1), 8–25.
Leonard Ikenna Chielo, Tom Pike, and Jonathan Cooper. (2016). Ranging Behaviour of Commercial Free-Range Laying Hens. National Center for Biotechnology Information. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4880845/.

Liew, Pit Sze, A Mat Isa, Nurulfiza,B,C Abdul Rahman, Omar,A,C, Ideris, Aini,A,C Mohd, Hair-Bejo. (2016). Pertanika Journal of Scholarly Research Reviews. 2(2): 23-39.

Lukert, P. D., J. Leonard, and R. B. Davis. (1975). Infectious bursal disease virus: Antigen production and immunity. American Journal of Animal and Veterinary Sciences. 36:539–540.

Lynch, D. (2009). Environmental impacts of organic agriculture: A Canadian perspective. Canadian Journal of Plant Science, 89(September 2008), 621–628.

Maas RA, Venema S, Oei HL, Pol JMA. Claassen IJTM, Huurne HM. (2001). Efficacy of inactivated infectious bursal disease (IBD) vaccines: comparison of serology with protection of progeny chickens against IBD virus of varying virulence. Avian Pathology; 30:345-354.

Markussen, M., Kulak, M., Smith, L., Nemecek, T., & Østergård, H. (2014). Evaluating the Sustainability of a Small-Scale Low-Input Organic Vegetable Supply System in the United Kingdom. Sustainability, 6(4), 1913-1945.

Marquart W. W., Snyder D. B., Yancey F. S. and Savage P. K. (2010). An enzyme-linked immunosorbent assay for the detection of antibody against avian influenza virus. Avian Diseases 29, 136–144.

Mbuko IJ, Musa WI, Ibrahim S, Sa'idu L, Abdu PA, Oladele SB, Kazeem HM. (2010). A retrospective analysis of infectious bursal disease diagnosed at Poultry Unit of Ahmadu Bello University, Nigeria. International Journal of Poultry Science 9: 784-790.

Minga, U.M., Katule, A.N., Maeda, T. and Musasa, J. (1989). Potential and problems of traditional chicken industry in Tanzania. In: Proceedings of the 7th Tanzania Veterinary Association Scientific Conference, Arusha International Conference Centre, Arusha, Tanzania, vol. 7, 207-215.

Mlozi M R S, Kakengi A. V. M., Minga U M, Mtambo A M and Olsen J. E. (2003). Marketing of free - range local chickens in Morogoro and Kilosa urban markets, Tanzania. Livestock Research for Rural Development, Volume 15.

Moraes HLS, Salle C. T. P., Nascimento V. P., Rocha A. C. G. P., Souza G. F., Furian T. Q., Artencio J. O. (2005). Infectious bursal disease: evaluation of maternal immunity and protection by vaccination of one day old chicks against challenge with a very virulent virus isolate. Revista Brasileira de Ciência Avícola; 7(1):51-57.

Moraes H. L. S., Salle C. T. P., Padilha A. P., Nascimento V. P., Souza G. F., Pereira R. A. (2004). Infectious bursal disease: evaluation ofpathogenicity of commercial vaccines from Brazil in specific pathogens free chickens. Brazilian Journal of Poultry Science 6(4):243-247.

Muskett J. C., Hopkins I. G., Edwards K. R., Thornton D. H. (1979). Comparison of two infectious bursal disease vaccine strains and potential hazards in susceptible and maternally immune birds. Veterinary Record 1979; 104:332-334.

Mwalusaya N. A., Katule A. M., Mutayoba S. K., Mtambo M. M. A., Olsen J. E. and Minga U. M. (2001). Productivity of local chickens under village management conditions. Tropical Animal Health. Production, 34: 405 -416.

Okoye J. O. A. & Uzoukwu, M. (1990). Pathogenesis of infectious bursal disease in embryonally bursectomised chickens. Avian Path. 19, 555 -69.

Paul, B. K., A. K. M. F. Huque, S. M. L. Kabir, J. Alam and S. C. Badhy. (2005). Evaluation of vaccination programmes against gumboro disease with persistence of maternally derived antibody in broiler chickens. Bangl. J. Vet Med. 3(1): 13-16.

Permin, A., Magwisha, H., Kassuku, A.A., Nansen, P., Bisgaard, M., Frandsen, F. and Gibbons, L. (1997). A cross-sectional study of helminths in rural scavenging poultry in Tanzania in relation to season and climate. Journal of Helminthology, 71, 233-240.

Phong, S.F., Hair-Bejo, M., Omar, A.R. and I. Aini. (2003). Sequence analysis of Malaysian infectious bursal disease virus isolate and the use of reverse transcriptase nested polymerase chain reaction enzyme-linked immunosorbent assay for detection of VP2 hypervariable region. Avian Diseases, 47:154-162.

Pollan, M. (2001). Naturally. New York Times. New York. Retrieved from http://www.nytimes.com/2001/05/13/magazine/naturally.html

Raji A. A., B. Mohammed, S. B. Oladele, L. Saidu, A. H. Jibril and C. Cazaban. (2016). Journal of Veterinary Medicine and Animal Health. Vol. 9(2), pp. 32-38.

Rigby, D., & Cáceres, D. (2001). Organic farming and the sustainability of agricultural systems. Agricultural Systems, 68, 21–40.

Roberts. (2008). The end of food (390 p.) Houghton Mifflin Company, Boston, USA.

Schader, C., Jud, K., Meier, M. S., Kuhn, T., Oehen, B., & Gattinger, A. (2014). Quantification of the effectiveness of greenhouse gas mitigation measures in Swiss organic milk production using a life cycle assessment approach. Journal of Cleaner Production, 73, 227-235.

Sharma J. M. (2000). Introduction to poultry vaccines and immunity. Adv. Vet. Med., 41, pp. 481-494.

Sossidou, E. N., Dal Bosco, A., Elson, H. A., & Fontes, C. M. G. A. (2011). Pasture-based systems for poultry production: Implication and perspectives. World's Poultry Science Journal, 67, 47–57.

Zanusso, J. T., & Dionello, N. J. L. (2003). Alternative poultry production: Analysis of the qualitative factors of the meat of broiler chickens. Brazilian Journal of Agrociência, 9, 191–194.

Stoute S. T., D. J. Jackwood. (2013). Molecular evidence for a geographically restricted population of infectious bursal disease viruses Avian Dis., 57 (2013), pp. 57-64.

Tadelle D and Ogle B., 1996. A survey of village poultry production in the central highlands of Ethiopia. (M.Sc. Thesis) Swedish University of Agriculture Science Pp.22.

Thorton, D.H. and M. Pattison, (1975). Comparison of vaccine against infectious bursa disease. J. Comparative Pathology. 85:597-610.

Thu-Zar, T. and H. Hafiza, (1994). Isolation, identification and pathogenicity studies of local isolates of IBD virus. Master Thesis, University Pertanian Malaysia, Malaysia.

Tuomisto, H. L., Hodge, I. D., Riordan, P., & Macdonald, D. W. (2012). Does organic farming reduce environmental impacts? - A meta-analysis of

European research. Journal of Environmental Management, 112(834), 309–320.

Van den Berg T. P., D. Morales, N. Eterradossi, G. Rivallan, D. Toquin, R. Raue, K. Zierenberg, M.F. Zhang, Y.P. Zhu, C.Q. Wang, H.J. Zheng, X. Wang, G.C. Chen, B.L. Lim. (2004). Assessment of genetic, antigenic and pathotypic criteria for the characterization of IBDV strains Avian Pathol., 33 pp. 470-476.

Van den Berg T. P., Eteradossi N., Torquin D., Muelemans G. (2000). Infectious bursal disease. Rev. Sci. Tech. Off. Int. Epiz, 19:527-543.

Van Herdeen K., Cazaban C., Alva B. (2011). The Relevance of Bursa Size in Modern Poultry Production. August 2011. Pluimvee Poult. Bull. pp. 24 -26.

Walt Van der J. G, Iji P. A., Brand T. S., Boomker E. A., Booyse D. (2006). Development of the digestive tract in the ostrich (Struthio camelus). Arch. Tierernahr. 57:217–228.

Weber, C. L., & Matthews, H. S. (2008). Food-miles and the relative climate impacts of food choices in the United States. Environmental Science & Technology, 42(10), 3508–13. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/18546681

Weiss, E. and I. Kaufer-Weiss. (1994). Pathology and pathogenesis of infectious bursal disease, J. Comparative Pathology, 85:597-610.

Weiss, F., & Leip, A. (2012). Greenhouse gas emissions from the EU livestock sector: A life cycle assessment carried out with the CAPRI model. Agriculture, Ecosystems & Environment, 149, 124–134.

Winterfield, R.W. and H.J. Thacker. (1978). Immune response and pathogenecity of different strains of infectious bursal disease virus applied as vaccine. Avian Diseases, 22: 721 731.

Wolfe, H. R., S. A. Sheridan, N. M. Bilstad, and M. A. Johnson. (1962). The growth of lymphoid organs and the testes of chickens. Anat. Rec. 142:485–493.

Yan, M.-J., Humphreys, J., & Holden, N. M. (2011). An evaluation of life cycle assessment of European milk production. Journal of Environmental Management, 92(3), 372–9.

Yongolo, M.G.S., (1996). Epidemiology of Newcastle disease in village chickens in Tanzania, (MVM Dissertation, Sokoine University of Agriculture, Tanzania).

Zhai, L., Y. Wang, J. Yu and S. Hu. (2014). Enhanced immune responses of chickens to oral vaccination against infectious bursal disease by ginseng stem-leaf saponins. Poultry Science, Volume 93, Issue 10, Pages 2473–2481.