Developments in chick vaccination

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The criteria for successful animal or veterinary vaccines can be very different from those for human vaccines depending on the animal groups under consideration.

For example, criteria for companion animal vaccines are similar to those for human vaccines in that the health and welfare of the individual animal are primary concerns.

The main objective of livestock vaccines, on the other hand, is to improve overall production for the primary producers, and the cost-benefit resulting from vaccination is the bottom line for this industry.

Mass vaccine application

In the poultry industry, vaccination techniques must be very practical and applicable on a flock basis. Flock sizes of commercial poultry operations can be as high as 30,000 birds per house.

For this reason it has become necessary to evolve effective methods of mass vaccination.

The aim is to vaccinate a high enough proportion of the birds in the flock, to prevent or minimise the effect of a particular disease.

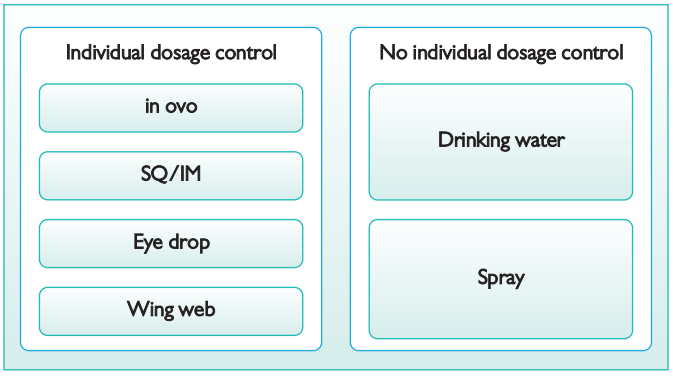

Fig. 1. Poultry mass vaccination techniques.

Some of the most common administration techniques used in the industry are:

- Drinking water.
- Spray/nebulisation – at day of age. Birds in the housed environment.
- Eye drop.
- Transfixion and scarification (cutaneous route in the wing web or foot).
- Injection – intramuscular or subcutaneous.
- In-ovo administration.

These mass administration techniques can be divided into two groups – with individual dose control and without individual dose control (Fig. 1).

The individual dosage control techniques are more effective in delivering the vaccine to most of the birds in the flock which helps to assure the vaccine efficacy. The disadvantage of these techniques is the amount of labour, time and bird handling that is required in order to properly vaccinate the flock.

However, the automation of these procedures, such as the in ovo technique, allows more uniform and fast vaccine application, a significant improvement in labour efficiency and less stress on the hatched chick when compared to day of age manual vaccination.

In ovo vaccination

In the broiler industry in the USA the proportion of vaccines applied in the hatcheries increased from 69.7% in 2001 to 87.9% in 2010 with a significant amount of these vaccines administrated by spray cabinets in the hatchery (49.4%), followed by the in ovo vaccination route (38.5%) (see Fig. 2)

However, from the vaccine value perspective the industry moved from US$ 27.5 million applied in the hatchery in 2001 to US$ 60.5 million in 2010 and most of them (55.2%) were administrated in ovo (see Fig. 3).

Vectored vaccines

One factor that has impacted this trend to apply the vaccines in the hatchery, whether in ovo or by other mass vaccination technique with individual dosage control, is the appearance of recombinant vectored vaccines in the market.

The live vectored vaccines use recombinant DNA technology to facilitate the expression of genes encoding antigenic proteins from more than one pathogen in appropriate viruses.

Such vaccines offer efficient means of delivering specific genes products of pathogens and thereby controlling multiple disease conditions.

In 16 countries around the globe the vector vaccines sales grew 16% from 2009 to 2010, indicating the industry increased interest in this type of technology (Table 1).

Currently there are 12 commercially licensed recombinant vaccines for poultry in the USA (Table 2)

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Fig. 2. Vaccine injections by application point: hatchery (spray cabinet), in ovo or in the field.

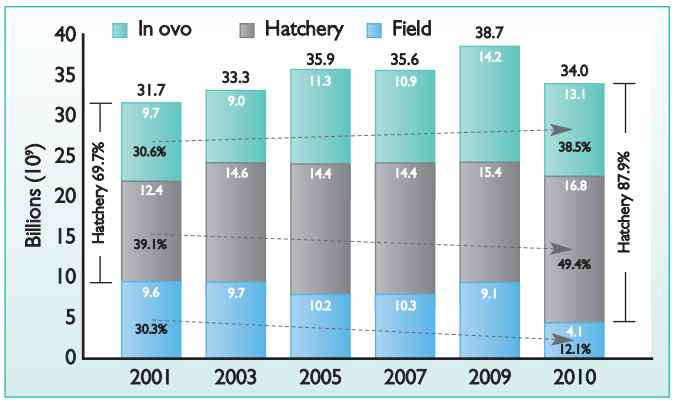
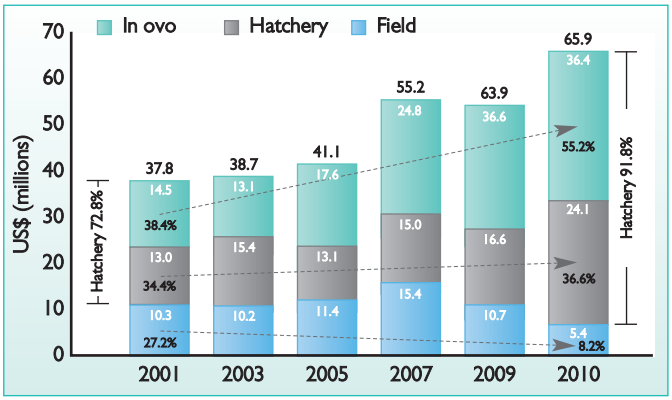


Fig. 3. Vaccine value by application point: hatchery (spray cabinet), in ovo or in the field.



Key countries/ markets where vector vaccines are sold	2009 sales (US$ MM)	2010 sales (US$ MM)	2009-2010 growth (%)
United States	27.08	28.22	4.21
Brazil	10.48	12.40	18.39
Mexico	6.33	8.09	27.86
Italy	3.06	3.01	-1.49
France	1.91	2.46	28.95
Canada	0.86	1.98	129.54
China (+ Hong Kong)	NA	0.97	NA
Spain	1.04	0.96	-7.18
Netherlands	0.35	0.89	156.39
United Kingdom	0.22	0.69	211.69
Greece	0.39	0.63	60.51
Portugal	0.37	0.28	-23.96
Poland	0.15	0.14	-6.45
Belgium	0.09	0.13	48.97
Germany	0.04	0.06	50.05
Hungary	0.08	0.05	-36.00
Total	52.44	60.97	16.26

Table 1. Vector vaccines market: size and growth.

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which are based on fowlpox virus (FPV) and herpes virus of turkey (HVT) vectors.

DNA vaccines

The gene encoding the immunogenic protein(s) is inserted into an appropriate eukaryotic expression plasmid that can be replicated in bacteria, purified and then directly inoculated by various methods into the animal to be vaccinated (Fig. 4). The plasmid insert is then expressed by the host cells and the protein produced initiated an immune response. DNA vaccination offers several advantages for delivering protective antigens:

- DNA vaccines mimic a natural viral infection in that the antigens they encode are produced in the native conformation and are presented in the context of major histocompatibility complex (MHC) class I and II evoking a balance immune response.
- There is no evidence of injection-site reactions or reversion to wild type.
- Neonates can be immunised with minimal interference from maternal antibodies.
- DNA vaccines are easily generated and manufactured in a relatively cost effective manner.
- DNA vaccines are stable at high ambient temperatures removing the need for maintaining a cold chain.

The DNA vaccines can and do work in the avian species, however not always resulting in protection.

Initial studies have shown that DNA can be delivered in ovo and topically with resulting protein expression.

If DNA vaccines are to be used in the poultry industry they must be able to be delivered easily and en masse, they must be efficacious and they must be affordable.

Adjuvants

The advances in avian immunology knowledge, including the innate immune response, the role of chemokines/cytokines, antigen processing and presentation, cell mediated and mucosal immunity, to some extent have been crucially important to shift the emphasis on adjuvant research.

Developing adjuvants that initiate the immune response more optimally may be unable to lower the antigen dose, decrease the amount of vaccine boosters, obtain a faster onset of immunity, whilst maintaining a long duration of immunity.

Modern immunological concepts have helped in understanding that vaccines, consisting of replicating or non-replicating attenuated pathogens or whole inactivated micro-organisms, contain 'intrinsic immunodefence triggers' called Pathogen Associated Molecular Patterns (PAMPs), which are part of the pathogen structure.

The innate immune system can identify the so called 'danger signals' such as PAMPs and quickly respond to them.

Some inactivated and highly purified vaccines lose part of their intrinsic immunostimulatory ability due to the inactivation and purification process where immuno defence triggers are mostly removed.

The combination of antigens and adjuvants has allowed for the development of highly immunogenic new vaccines which provide an increased modulation of innate and adaptive immune responses leading to effective protection against infection.

Conclusions

The in ovo technique offers several advantages that make the mass vaccination process more effective and reliable and become a preferred delivery system for the higher value, new generation of vaccines.

The recombinant vaccines have brought new tools to fight several diseases and their usage has increase in recent years.

These vaccines have been constructed using fowl poxvirus (FP) or herpesvirus of turkey (HVT) as vectors, with insert genes from one virus or bacterium only ('monoinsert' vectors). The DNA vaccine efficacy in chickens requires more research, however the advances in immunostimulating factors (CpG motifs, cytokines, chemokines and co-stimulatory molecules), the ability to targeting the vaccine to professional APCs (antigen presenting cells), better delivery techniques and alternate prime-boost strategy are some of the avenues available for potentially enhancing DNA vaccine efficacy in chickens.

For many reasons including reduction of the duration of the growing period for broilers, increasing labour cost, difficulties to find properly trained or motivated operators at the farm, availability of hatchery adapted vaccination equipment (in ovo, spray cabinet, subcutaneous injectors) and new types of vaccines; vaccination at the hatchery is becoming more and more common in the poultry industry. ■

References are available from the author on request

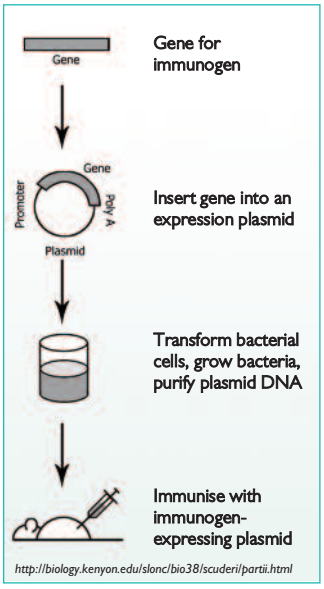

Fig. 4. The principle of DNA vaccination.

Table 2. Currently licensed recombinant vaccines for poultry (Veterinary Biological Products, USDA, 2011).

Vector	Immunogen	Company
Fowl poxvirus	Avian Influenza virus	Merial
	Newcastle disease virus	Merial
	Mycoplasma gallisepticum	Ceva/Biomune
	Infectious laryngotracheitis virus	Ceva/Biomune
Herpes virus of turkey	Newcastle disease virus	Ceva/Biomune
	Newcastle disease virus	Intervet/Schering Plough
	Infectious bursal disease virus	Merial
	Infectious bursal disease virus	Ceva/Biomune
	Infectious laryngotracheitis virus	Ceva/Biomune
	Infectious laryngotracheitis virus	Intervet/Schering Plough
	Marek's disease virus (serotype 1)	Intervet/Schering Plough
	Marek's disease virus (serotype 1) + Newcastle	Intervet/Schering Plough

Fig. 5. Adjuvants classification (Adapted from Leroux-Roels, G).