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Innovative Anti-parasitic Vaccines: Revolutionizing Livestock Veterinary Care

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Abstract: Parasitic diseases are a major concern worldwide since they adversely affect animals' health and threaten production of profitable animal and directly or indirectly affect humans. These cause high mortality and morbidity rate since these are also involved in spread of zoonotic diseases and cause worldwide economic losses. Several approaches have been employed to reduce parasitic infections including veterinary vaccines for livestock. Vaccination is the most sustainable approach to control parasitic diseases. It increases the initial cost but also provides long lived immunity and improves animal health including human health by controlling the source of foodborne parasitic diseases (FBDs). But resistance to multiple drugs has been increasing in parasites drastically also the residues of drugs remain in the meat, milk and milk derived products due to the lack of development of new effective drugs. These are the main reasons of vaccines production. In the present review, advances in development of vaccines have been discussed to control parasitic diseases since they have various mechanism of invasion in host body that make it difficult to produce vaccines.

Keywords:

Parasitic diseases, foodborne diseases, drug resistance, parasitic vaccines.

Introduction

Parasitic diseases that degrade the productivity of animal can destabilize the food supplies and can be economically devastating [1]. Transmission of zoonotic diseases is a significant threat to global health. There is a wide array of strategies to control livestock parasitic diseases including sanitation, culling of affected animals, antibiotics use, biological control, grazing management, increasing genetic resistance of hosts, and vaccination [2].

Vaccines are biological products produced to prevent or reduce infectious diseases by inducing immune responses against specific pathogenic microorganisms [3]. To prevent animal diseases, enhancement of animal food production and reducing the transmission of zoonotic diseases and FBDs, veterinary vaccines are the efficient method [4]. Brucellosis, leptospirosis, and trypanosomiasis would be much more prevalent in humans without effective vaccination of animals. Rinderpest is another highly contagious disease that affect cattle and buffaloes, is an example of combined effect of vaccination with other control measure to improve animals and humans' health [5]. Increased use of veterinary vaccines and continuous improvement of vaccines is essential to promote the animal welfare, reduce economic losses, and efficient food production [6]. Vaccines should be affordable to increase their use for positive effect on animal and public health. This review comprehends the advances, benefits, success and challenges of veterinary vaccines development for livestock species as a parasitic control strategy.

Types of vaccines

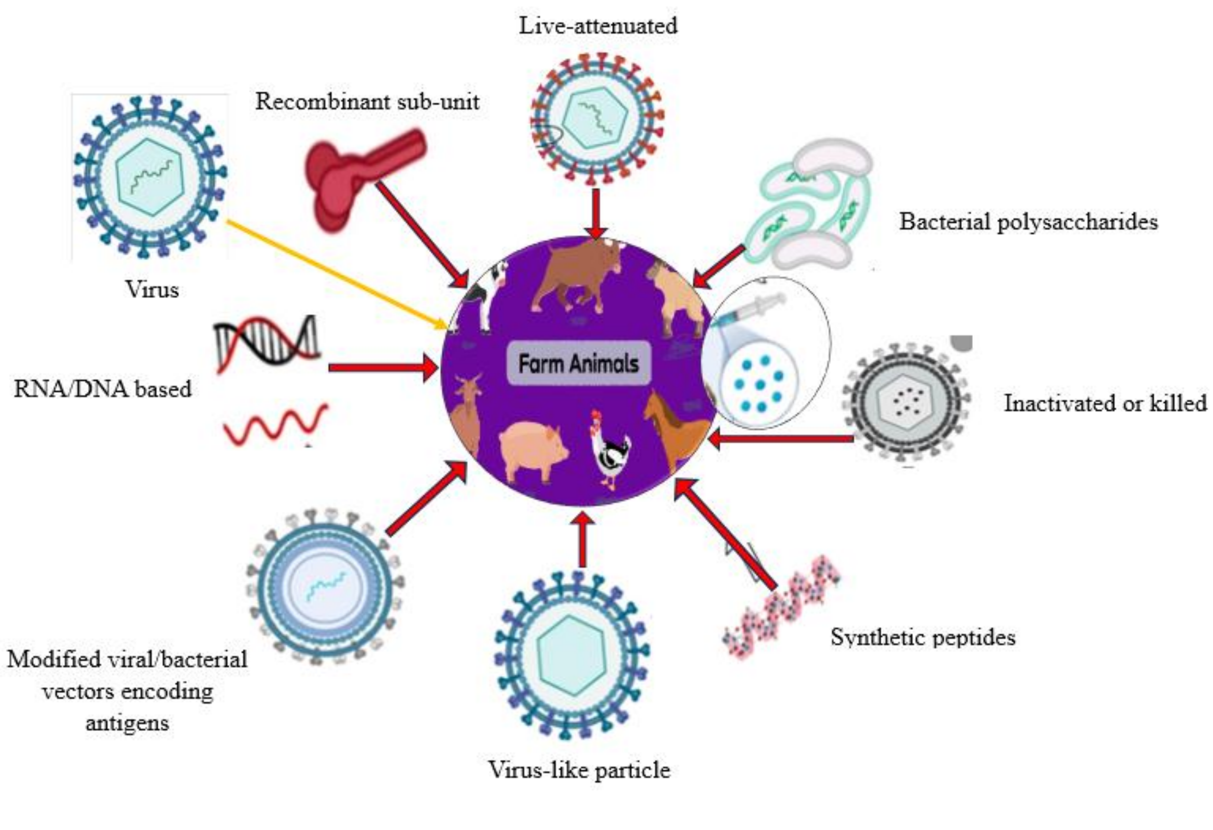

Fig 1: Veterinary antiparasitic vaccines

(Talib et al., 2024)

Table 1: Livestock vaccines against foodborne parasites

Foodborne pathogen	Specie	Vaccine type	Outcomes	References
T. solium	Pigs	Recombinant protein	Reduction in number of cysticerci	[7,8]
T. solium	Pigs	Bacteriophages	Reduction in number of cysticerci	[9]
T. gondii	Sheep	Attenuated strain	Increase number of viable lambs	[10]
T. gondii	Sheep	DNA	Not determined	[11,12]
T. gondii	Pigs	Live strain	Reduction in parasite load and number of infected pigs	[13,14]
T. gondii	Pigs	Protein extract	Reduction in number of infected pigs	[15,16]
T. gondii	Pigs	DNA	Reduction in number of infected pigs	[17]
T. spiralis	Pigs	Protein extract	Protection against	[18,19]

			challenged infection and reduction in recovery of infective larvae	
E. granulosus	Cattle	Recombinant protein	Reduction in number of cysts in vaccinated cow and calves born from them	[20]
C. parvum	Cattle	Attenuated strain	Reduction in shedding of oocyst and diarrhea	[21]
C. parvum	Cattle	Recombinant protein	Reduction in oocyst shedding and diarrhea in calves fed with colostrum from vaccinated cows and delayed its onset	[22]

Vaccines for food production and food safety

Adequate animal production and better access to high attributed proteins are crucial to meet the feed requirement of growing population. Therefore, veterinary vaccines are used in poultry to support animal health and gain better production. But some countries do not have access to licensed vaccines as some producers cannot afford those [23]. Vaccines against specific pathogen in specific region or country is available but due to the cost lack of availability some other countries are likely to have insufficient access to effective vaccines [24].

In many parts of the globe foot and mouth disease (FMD) virus is formidable concern to meat and dairy production. 2% of cattle are infected with FMD virus each year all over the world [25]. In China, Africa, and India; about 7.6billion $ production loss occur every year due to the FMD [25]. This directly cause diminished animal weight gain and milk production and indirectly cause economic losses due to restricted livestock exportation. Veterinary vaccines are effective in protection against FMD in cattle, buffaloes, and pigs where this disease is endemic. This could be having more positive impact on economy if vaccination of FMD would has long lasting effect of induced immunity and less expensive [26]. Antibiotics are available for reducing bacterial infections in livestock but there is increasing concern about antibiotic resistance associated with the more use of human and animal antibiotics as medicines [27]. If both antibiotics and vaccines are available for specific disease like swine ileitis can be controlled either by vaccination or antibiotics, so producers must choose one of them which could be more cost effective. Affordable vaccines reduce dependence on antibiotics for maintaining animal health [28].

Latterly, vaccines are developed for controlling the pathogens that cause FBDs in people. Vaccines are now available for *E. coli* O157:H7 in cattle, *Serovas enteritidis*, *Salmonella enterica*, and *typhymurium* in chickens. These vaccines reduce shedding of pathogens and intestinal colonization that may cause animal products contamination that are feed by humans and thereby promote overall animal health [29, 30]. In future, there may be increase in use of veterinary vaccines for protecting FBDs.

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Table 2: Commercially available anti-parasitic vaccines

Parasite	Host	Vaccine type	Results	References
T. gondii	Sheep	For truncated lifecycle attenuated vaccine	Reduce congenital infection in ewes	[31]
T. parva	Cattle	Non attenuated	Controlled infection by sporozoites	[32]
T. annulata	Cattle	Attenuated cell line vaccine	Protection against schizonts	[33]
T. ovis	Sheep	Subunit recombinant vaccine	Interfere with attachment of parasite to gut wall	[34]
Eimeria spp.	Chickens	Live virulent	Infection immunity against oocyst	[35]
Eimeria spp.	Chickens	Attenuated for precocity	Infection immunity by using precocious lines	[35]

E. maxima	Chickens	Subunit vaccine of gametocyte antigen	Induce maternal immunity	[36]
Rhiphicepahalus microplus	Cattle	Recombinant vaccine	Protein is found in tick at the surface of gut wall	[37]
B. canis	Dog	Subunit vaccine	Neutralize soluble parasite	[38]
B. bovis & B. bigemina	Cattle	Attenuated vaccine	Immunity against merozoites	[39]
G. duodenalis	Dogs	Killed vaccine	Reduce incidence and duration of cyst shedding	[40]
N. caninum	Cattle	Killed vaccine	Reduce abortion due to tachyzoites	[41]

Vaccines to control zoonotic diseases

Control of zoonotic diseases in household animals, food animals and even in wild animals have had positive impact on controlling zoonotic diseases in people [42]. Leptospirosis, rabies, Hendra, rift valley fever, Q fever, Nipah, brucellosis, influenza and Japanese encephalitis are the zoonotic diseases that can be controlled in animals by vaccination and thereby control their transmission to people [42]. Dogs and cats could not be expected ad pets without rabies vaccine. Incidence of rabies in wild animals like baits has been reduced by the use of oral vaccine (recombinant vaccinia-vectored rabes vaccine) [43].

Brucellosis in cattle, small ruminants and people was a major concern due to the lack of available brucella vaccines for animals. Live vaccines of brucella are major problem because they can cause symptoms and infection in people [44, 45]. New generation of brucellosis safer vaccines are needed. Leptospirosis in humans cause miscarriage and fatality. Livestock vaccination against *Leptospira serovars* can reduce incidence of leptospirosis in humans [46].

Increase in population of humans and animals cause global warming, environmental degradation and spread of arthropod vectors. Global travel also causes increased transfer of pathogens within and between species. This results in enormous challenges for protection against diseases in present and future [47].

There are various examples of viruses against which vaccines are developed successfully, for example West Nile, Venezuelan equine encephalitis, and Hendra [48, 49]. Avian influenza strain H5N1 in chickens has been controlled in many by combining vaccination and other eradication strategies. In China, several billions of doses of vaccines were administered [50]. Prime of animal vaccine development is now seen a Rift valley fever virus that is a zoonotic agent and devastating pathogen of ruminants [51]. Regular advancement in production of more cost effective, safe, and efficient vaccines against zoonotic diseases will improve human and animal health and food production.

Success and challenges

Global control and eradication of rinderpest virus is one of the greatest successes. A conventional live-attenuated virus was developed by the repeated passages of virulent rinderpest strain from calf kidney cells, act as a Plowright vaccine against rinderpest virus [52]. Another important striking example in success and challenges of vaccines can be seen in swine viruses. Aujeszky's disease virus that is also known as pseudorabies virus, has been removed from herd in many countries.

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This is achieved by glycoprotein gene deletion in vaccines [53, 54]. This strategy acts a diagnostic tool to differentiate between infected and vaccinated animals. Significant improvement in productivity and health of swine is attained by commercial development and use of inactivated virus vaccine for porcine circovirus 2 (PCV2) [55].

Unfortunately, vaccines against influenza a virus of swine (IAV-S) and porcine reproductive and respiratory syndrome virus have been shown less successful due to antigenic variability of these viruses. One effective method to control these variable viruses or others like them, is to identify their epitopes that remain highly conserved across many strains. These vaccines may provide broad cross protection [56]. Other methods for efficient vaccines production against these viruses include, utilizing new adjuvants, delivery mechanisms rationally developed live-attenuated viruses, and delivery mechanisms. Newcastle disease virus vaccines are widely used in endemics of some countries but still cause frequent outbreaks that may be due to genetic changes in pathogens that aid them to evade immunity induced by vaccines [57].

Veterinary vaccines financial returns are much less than that of humans' vaccines that is a major drawback of veterinary vaccine development. Their market value and sales prices are lower. So, there is less investment in research and development of veterinary vaccines as compared of humans [58].

Conclusion

It is concluded that the effects of infectious diseases of livestock and domesticated animals are seen all over the world, reckless of veterinary medical infrastructure. Often, public health is put at risk when global food production diminished due to uncontrolled livestock diseases. It is foreordained that the world will continue to face the emergence of new animal and human diseases in the coming decades. This protest demands that public health, veterinary, and medical communities should work in group locally and internationally. To ensure food safety, food security, human health, and animal health; safe, effective, and affordable veterinary vaccines are important tool.

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