Table 2
Comparative analysis of efficacy profiles of vaccine platforms

Vaccine type	Parameter					
	Immunogenicity	Overcoming maternally derived antibodies (MDA)	DIVA status	Convenience / administration route	Biosafety	Main area of application
Conventional live vaccines (attenuated): LaSota (SEVAK® ND-IB K, Hungary), B1 (Gallivac® B1, France), Clone 30 (Nobilis® ND, Netherlands), VG/GA (Avinew®, Germany) [38, 59, 60]	*Clinical protection:* 100% protection against mortality and clinical manifestations. *Virus shedding:* reduced but not completely prevented when the field virus belongs to a different genotype. *Type of immune response:* rapid production of serum antibodies in high titres (hemagglutination inhibition); with drinking water or spray, mucosal immunity is formed in the respiratory and gastrointestinal tracts	Low (neutralized); creates an "immune window"	Incompatible	High / suitable for all types of large-scale immunization: spray (fine and coarse), with drinking water	Low/ moderate (risk of post-vaccination reactions)	Emergency protection, revaccination
Recombinant vector vaccines: Vectormune® ND (Hungary), Innovax® ND (USA), Trovac® NDV (Germany) [31, 36]	*Clinical protection:* up to 90–100% protection against mortality and clinical manifestations (formed by the 3rd–4th week of life). *Virus shedding:* significantly reduced, but due to low local immunity, the field virus may be isolated in the first days after infection. *Type of immune response:* low/moderate antibody titres, powerful cellular immunity, low mucosal immunity	High	Compatible (differentiating marker – nucleoprotein, NP)	High, but specific / ideal for automated vaccination in hatcheries (*in ovo*, subcutaneously). Unsuitable for administration with drinking water or for spray administration	High (non-pathogenic vector)	Basic protection in hatcheries
Vaccines based on reverse genetics technologies (genotype-matched): local products in China, South Korea, Mexico – strains based on chimeric LaSota strain with genotype VII *F* gene [36, 41, 61]	*Clinical protection:* up to 100% protection against mortality and clinical manifestations. *Virus shedding:* maximum reduction of the virus shedding. Genetic matching of the vaccine and field virus strains completely blocks the virus shedding. *Type of immune response:* high titres of the virus neutralizing antibodies, cellular immunity, mucosal immunity	Low/Medium	Potentially compatible (depends on the design)	High (similar to conventional vaccines)	Moderate, requires control (GMO virus)	Eradication in endemic areas
Subunit and VLP vaccines: commercially not widely used, there are inactivated emulsion vaccines from regional manufacturers [48, 62]	*Clinical protection:* moderate to high (80–100%), protection depending on the adjuvant used. *Virus shedding:* significantly reduced, especially when the antigen is homologous to the field strain, but not completely prevented. *Type of immune response:* forms a strong humoral response, cellular immunity is poorly expressed, mucosal immunity is virtually absent	Moderate (at a high dose)	Compatible	Low / requires individual injections (labor-intensive for broilers, acceptable for the parent flock)	Absolute (no replication)	Protection of breeding stock

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	Immunogenicity	Overcoming maternally derived antibodies (MDA)	DIVA status	Convenience / administration route	Biosafety	Main area of application
DNA vaccines: at the stage of experimental development and clinical trials [63, 64]	*Clinical protection:* variable. Under controlled conditions, it can reach 90–100%; it is extremely low without special delivery methods in the field. *Virus shedding:* decreased, but significantly to a lesser extent compared to all of the above vaccines. *Type of immune response:* both humoral and cellular immunity are induced, however, the resulting antibody titres are usually low	Medium/High	Compatible	Low (at the current stage) / effective methods of mass delivery (aerosol/water) have not been developed	High	Promising developments