Livestock Science 190 (2016) 10–15

Contents lists available at ScienceDirect

Livestock Science

journal homepage: www.elsevier.com/locate/livsci

Influence of four commercial porcine circovirus type 2 (PCV2) vaccines on the improvement of production parameters in pigs with maternally derived antibodies

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ARTICLE INFO

Article history:
Received 25 October 2015
Received in revised form
25 May 2016
Accepted 26 May 2016

Keywords:
Vaccine efficacy
Porcine circovirus type 2
Sow
Piglet
Maternally derived antibodies
Production parameters

ABSTRACT

Anti-PCV2 antibodies in serum, viremia and production parameters (average daily weight gain [ADWG] and mortality) were assessed in piglets immunized with four commercial PCV2 vaccines in the presence of high levels of maternally derived antibodies (MDA). A total of 217 sows were vaccinated (V) at 7 and 4 weeks before farrowing with an inactivated PCV2 vaccine. All piglets derived from these sows (n=2215) were divided into five groups and 3-week-old piglets were injected with one of four different vaccines (A-D): V sows-VA piglets (n=437), V sows-VB piglets (n=424), V sows-VC piglets (n=432) and V sows-VD piglets (n=417). A control group of non-vaccinated piglets (V-NV, n=426) received phosphate-buffered saline (PBS). Sows (n=39) received PBS (non-vaccinated group). The ADWG of vaccinated piglets (V-VA, V-VB, V-VC and V-VD) ranging from 661 to 669 g/day were significantly higher than the control group (V-NV, 630 g/day), but differences in ADWG between vaccinated groups were not statistically significant. An overall mortality ranging from 7.23% to 9.20% was observed in vaccinated piglets (V-VA, V-VB, V-VC and V-VD) compared with the control group (V-NV, 20.02%). The number of genomic copies of PCV2 in serum for the control group were significantly higher than those of the four vaccinated groups at 10, 15, and 22 weeks of age. Vaccination increased serum antibodies in sows 3- to 4-fold; PCV2-specific antibody titers in sera from piglets were very similar to those of their sows. The antibody titers in vaccinated piglets and V-NV group decreased gradually about 3-fold until the week 10. In the presence of high MDA levels, piglets immunized with four commercial PCV2 vaccines showed a significantly reduction of PCV2 infected pigs, viral load, number of PCV2-sero positive pigs and mortality rate as well as significantly higher ADWG than those of the V-NV group.

1. Introduction

Porcine circovirus type 2 (PCV2) is recognized as the causative agent of several clinical diseases and syndromes, collectively known as porcine circovirus-associated disease (PCVAD). PCV2 prevalence is highly variable, causing significant economic losses worldwide, mainly due to increases in mortality and decreased weight gain. Postweaning multisystemic wasting syndrome (PMWS) is the most significant manifestation, a disease characterized by clinical signs such as wasting, reduced weight gain, pallor of the skin, respiratory distress, diarrhea, and occasionally, icterus (Rosell et al., 2000; Segalés, 2012).

Passive immunity is the primary protection against infections in early live of neonates. It is widely believed that the main limitations of the immunization of neonates from vaccinated sows is the interference with maternal antibodies (Hodgins and Shewan, 2012). Ideally, PCV2 vaccination should be administered while residual MDA are minimal and before pigs become fully susceptible to infection (Chae, 2012). The transfer and persistence for 1–2 weeks of maternal cytokines such as IL-4, IL,6, IL10, IL12 and IFN-γ from sows colostrum/milk to neonates, is well documented (Nguyen et al., 2007).

Vaccination of sows and gilts increases PCV2-specific neutralizing antibodies (NA) in colostrum, reduces viremia and systematic PCV2 load, and improves production parameters of their piglets in field conditions (Pejsak et al., 2010; Gerber et al., 2011; Kurmann et al., 2011). The induction of PCV2-specific neutralizing antibodies and interferon γ-secreting cells (IFN-γ-SCs) by commercial subunit and inactivated vaccines have coincided with

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http://dx.doi.org/10.1016/j.livsci.2016.05.013
1871-1413/

reductions in the PCV2 viremia (Fort et al., 2009a, 2009b; Opriessnig et al., 2010; Oh et al., 2012; Seo et al., 2012).

All commercial PCV2 vaccines have been developed to reduce PMWS impact in pigs by decreasing mortality and cull rates, frequency of coinfections, number of viremic pigs, viral load and viral-induced specific lymphoid lesions. In addition, PCV2 vaccination of piglets has been associated to significantly higher average daily weight gain (ADWG) (Fachinger et al., 2008; Horlen et al., 2008; Kixmöller et al., 2008; Ellis, 2014). The objective of this study was to compare anti-PCV2 antibodies in serum among vaccinated and non-vaccinated sows and subsequent vaccination/unvaccination of piglets, including viremia and production parameters of pigs under field conditions.

2. Materials and methods

This study was conducted between 2012 and 2013 in a farrow-to-finish farm. The system was experiencing high mortalities in the late nursery and/or early fattening pigs. PMWS was diagnosed using the internationally accepted criteria of clinical signs and gross lesions, histopathological findings and lymphocyte depletion of lymphoid tissues (Segalés et al., 2005). The farm located in South-Eastern Mexico with a strict all-in/all-out production system was maintained in the farrowing, nursery and fattening units. The reproductive herd consisted of 4500 sows and every week batch of 170–180 pregnant sows were introduced into farrowing houses. Piglets were weaned about 21 days (3 weeks) of life and then transferred into nursery units. At about 70 days (10 weeks) of life they were moved to the fattening units. The farm was seropositive but stable to porcine reproductive and respiratory syndrome virus, seronegative for swine influenza virus and *A. pleuropneumoniae*. Piglets were vaccinated for *H. parasuis* (weeks 1 and 3).

2.1. Sow and piglet experiment design

The control of PCVAD is based on vaccination against PCV2 and management strategies. Four commercial PCV2 vaccines registered for their application in piglets are currently available in Mexico. However, the four vaccines vary in the nature of the antigen, adjuvant types, recommended use (sows, piglets or sows and piglets) and in the dose of administration (Beach and Meng, 2012; Chae, 2012). Two of these vaccines (CircoFLEX®, Boehringer Ingelheim; Circumvent® PCV, Intervet/Merck) are subunit vaccines based on an open reading frame (ORF2) protein expressed in the baculovirus system. Circovac® (Merial) is composed of an inactivated, oil-adjuvanted PCV2a vaccine for use in sows, gilts and piglets. Fostera® PCV (Zoetis) has been introduced to the market, which is an inactivated attenuated chimeric PCV1-2 virus, containing the ORF2 capsid gene of the PCV2a cloned into the genomic backbone of the non-pathogenic PCV1 (Chae, 2012).

A total of 256 sows were used in the study, the dams were divided into 2 groups according parity: 217 were vaccinated twice, before farrowing (weeks 4 and 7) with 2 ml of vaccine B (Circovac, Merial) intramuscularly at the neck muscles, and 39 dams served as control group and received 2 ml of phosphate buffer saline (PBS) (non-vaccinated group); sows were mingled in the same farrowing and gestation units. Sow distribution, parity mean, piglets delivered and stillborns is shown in Table 1A. Three hundred seventy-three piglets (males and females) from non-vaccinated sows were injected with PBS (NV-NV group). The offspring of vaccinated sow were assigned to five groups: V-VA, V-VB, V-VC, V-VD (four commercial vaccines) and V-NV (control, Table 1B); being balanced by weight and sex, using a double blinded (neither the farmer nor the veterinarian knew which treatment was administered), controlled trial. The animals were individually identified with an ear tag at weaning. Piglets of each group were injected intramuscularly with PCV2 vaccines A (Fostera PCV, 2 ml, one dose at 3 weeks of age); B (Circovac, 0.5 ml, one dose at 3 weeks of age); C (Circoflex, 1 ml, one dose at 3 weeks of age), or D (Circumvent PCV, 2 ml, two doses at 3 and 6 weeks of age) according to each manufacturer's protocol. Three hundred seventy-six pigs were injected with PBS (V-NV group). All vaccinated and non-vaccinated piglets stayed comingled for the entire duration of the trial in the nursery and in the fattening facilities. This study was approved by the Animal Care and Ethics Committee of Meritorious Autonomous University of Puebla and all procedures complied with National Legislation Pertaining to Animal Health Research.

2.2. Sample collection

The sows were sampled three times during gestation by venipuncture from the jugular vein using vacutainers tubes (Becton Dickinson, USA), 7, 4 and 2 weeks before the expected farrowing date. Blood was collected from the jugular vein of pigs at 1, 3, 6, 10, 15, and 22 weeks of age. Blood samples were centrifuged at

Table 1.
Descriptive statistics of sows (A) and piglets (B) included in the study.

(A)

Groups	Sows	Sow parity		Piglets	Born alive		Stillborn	Mummies
		Mean	95% CI		Mean	95% CI		
Non-vaccinated	39	4.53	3.95–5.11	390	10.00	8.05–11.95	22	9
Vaccinated	217	4.70	4.48–4.92	2215	10.21	10.11–10.31	87	44

(B)

Groups	Vaccinated		Piglets[a]	Birth weight (kg)		Gender ratio (male:female)
	Sows	Piglets		Mean	95% CI	
NV-NV	No	No	373	1.37	1.36–1.38	51.7:48.3
V-VA	Circovac	Fostera	437	1.43	1.42–1.44	46.7:53.3
V-VB	Circovac	Circovac	424	1.41	1.40–1.42	51.4:48.6
V-VC	Circovac	Circoflex	432	1.35	1.34–1.36	49.1:50.9
V-VD	Circovac	Circumvent	417	1.41	1.40–1.42	49.9:50.1
V-NV(control)	Circovac	No	426	1.43	1.42–1.44	50.7:49.3

[a] At 3 weeks.

2000 × *g* for 10 min, and serum was collected and stored at −20 °C until use.

2.3. Average daily weight gain and mortality rate

The ADWG in the study period (weeks 1–22) was calculated as live slaughter weight (g) minus the live birth weight (g) divided by age in days. For each vaccine, unvaccinated group and period, mortality rate was calculated as the number of pigs that died divided by the number of pigs initially assigned to that group within each period.

2.4. Serology to detect PCV2 antibodies

Serum IgG responses against PCV2 were performed using a commercially available competitive ELISA (Serelisa PCV2 Ab Mono Blocking System; Synbiotics Europe, Lyon, France). The results of individual serum (optical density [OD]), expressed as sample to negative corrected (SNc): $(OD_{individual\ serum} - OD_{positive\ control})/(OD_{negative\ control} - OD_{positive\ control})$ were transformed to ELISA units according to the manufacturer's recommendations.

2.5. Quantification of PCV2 DNA

DNA extraction from serum samples collected at 1, 3, 6, 10, 15, and 22 weeks of age was performed using the QIAamp DNA Mini Kit (Qiagen, Valencia, CA). Each DNA sample was used to quantify PCV2 genomic DNA copy numbers by quantitative PCR (qPCR) in an Stratagene Mx-3005P cycler (Agilent Technologies, USA) as described previously (Opriessnig et al., 2003). qPCR reactions were performed in duplicate, consisting of 2.5 μl DNA template, 400 nM each of forward (5′-TGGCCCGCAGTATTCTGATT-3′) and reverse (5′-CAGCTGGGACAGCAGTTGAG-3′) PCR primers, 300 nM of TaqMan probe (6FAM-CCAGCAATCAGACCCCGTTGGAATG-TAMRA) and 22.5 μl Brilliant qPCR Core Reagent kit (Stratagene, La Jolla, CA, USA). Amplification conditions were as follows: 95 °C for 10 min for initial denaturation followed by 40 cycles of amplification with denaturation at 95 °C for 15 s and annealing and extension at 60 °C for 1 min. Data were analyzed with the software package MxPro v4.00 (Stratagene, La Jolla, CA, USA). The number of copies per microliter standard DNA was quantified using a commercial qPCR kit. Values of viral copies per milliliter serum were transformed to $\log_{10}$.

2.6. Statistical analysis

Data were analyzed using the software IBM SPSS 20 for Windows (SPSS Inc., Chicago, USA). Normality of the examined variables and homogeneity of the variances were checked using the Shapiro-Wilk and Levene tests, respectively. Results between groups (ADWG, PCV2-specific IgG, viremia, percentage of positive samples) at each time point were analyzed with a repeated measures analysis of variance (ANOVA). Mortality rates were analyzed by Fisher's exact test. A $P \leq 0.05$ was considered significant.

3. Results

3.1. Production parameters

Clinical signs which were most prominent during the fattening period (between 10 and 22 weeks of age) when wasting, growth retardation, locomotory disorders and diarrhea were observed. ADWG for all five study groups and control group was calculated for the interval 1–22 weeks of age (Table 2). The ADWG of piglets vaccinated were significantly higher than V-NV. ADWG values between offspring from vaccinated sows ranging from 661 to 669 g/day during the study period ($P > 0.05$). Significant differences between NV-NV and V-NV pigs were observed ($P < 0.05$).

Percentage cumulative mortality rates during the study period (1–22 weeks) in vaccinated piglets (V-VA, V-VB, V-VC and V-VD) were 7.23%, 8.92%, 9.20% and 7.81%, respectively (Table 2). Cumulative mortality rate for NV-NV group (26.49%) in the present study was higher than in the control group (V-NV =20.02%). Cumulative mortality rates during the nursery and fattening period (weeks 3–22) ranging from 3.70% to 5.63% for V-VA, V-VB, V-VC and V-VD pigs, 16.40% in V-NV group, whereas NV-NV group was 22.14%. Mortality rate during the suckling period did not differ significantly between vaccinated pigs (V-VA, V-VB, V-VC and V-VD) and NV-NV group ($P > 0.05$). However, mortality rates during the nursery and fattening period were significantly ($P < 0.05$) lower for V-VA, V-VB, V-VC and V-VD groups than for NV ones (NV-NV and V-NV).

3.2. Serological analysis

At week 7 pre-partum, sows of both groups had comparable levels of PCV2-specific IgG (1433 and 1401) (Table 3A). In the subsequent samplings, vaccinated sows showed a continuous increase of anti-PCV2 IgG antibody titers, reached a peak at week 4 pre-partum (5838), and a slight decrease at week 2 pre-partum. However, at weeks 4 and 2, vaccinated dams had significantly higher titers against PCV2 than the non-vaccinated group ($P < 0.05$).

At 1 week post-partum, the antibody titers against PCV2 of all vaccinated groups (vaccine A-D) were high with a mean of 4968. At 3 weeks of age, V piglets showed comparable high levels of antibodies due to MDA (range, 3628–3832). Following vaccination, anti-PCV2 IgG antibody titers decreased until the week 10 post-partum (mean 1810), but increased sharply and reached a maximum at the week 22 (mean 10,017). No significant difference was detected between V-VA, V-VB, V-VC and V-VD groups until the end

Table 2.
Average daily weight gain (ADWG) and mortality rates during the study period in pigs immunized with four commercial vaccines against PCV2.

Groups	Daily weight gain*		Mortality rate			Total mortality (%)	
	Mean (g)	95% CI	Weeks 1-3	Weeks 3-10	Weeks 10-22	Weeks 1-22	Weeks 3-22
NV-NV	615[a]	613–616	17/390 (4.36%)[a]	39/373 (10.46%)[a]	39/334 (11.68%)[a]	26.49	22.14
V-VA	662[b]	661–663	16/453 (3.53%)[a]	10/437 (2.29%)[b]	6/427 (1.41%)[b]	7.23	3.70
V-VB	669[b]	668–670	15/439 (3.42%)[a]	13/424 (3.07%)[b]	10/411 (2.43%)[b]	8.92	5.50
V-VC	661[b]	659–662	16/448 (3.57%)[a]	14/432 (3.24%)[b]	10/418 (2.39%)[b]	9.20	5.63
V-VD	662[b]	661–663	16/433 (3.70%)[a]	9/417 (2.16%)[b]	8/408 (1.96%)[b]	7.81	4.11
V-NV (control)	630[c]	629–632	16/442 (3.62%)[b]	33/426 (7.75%)[c]	34/393 (8.65%)[c]	20.02	16.40

Different superscripts (a–c) within each column indicate significantly ($P < 0.05$) different values.

* Weeks 1–22.

Table 3.
IgG reactivity against PCV2 of the sera from sows vaccinated (A) at weeks 7 and 4 pre-partum and piglets vaccinated at 3 weeks, or 3 and 6 weeks post-partum (B).

(A)

Groups	Weeks pre-partum*					
	7		4		2	
	Mean	95% CI	Mean	95% CI	Mean	95% CI
Non-vaccinated sows	1433[a]	1328–1538	2066[a]	1953–2179	1509[a]	1387–1631
Vaccinated sows	1401[a]	1359–1448	5838[b]	5785–5891	5529[b]	5479–5579

(B)

Groups	Weeks post-partum*											
	1		3		6		10		15		22	
	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI
NV-NV	1811[b]	1768–1853	1539[b]	1507–1571	1154[b]	1133–1175	2541[b]	2519–2563	8345[b]	8324–8366	13,256[b]	13,234–13278
V-VA	4914[a]	4876–4953	3691[a]	3653–3728	2520[a]	2490–2550	1801[a]	1767–1836	5610[a]	5588–5631	9964[a]	9890–10039
V-VB	5022[a]	4988–5056	3651[a]	3609–3693	2644[a]	2612–2676	1780[a]	1746–1814	5681[a]	5658–5704	9967[a]	9889–10046
V-VC	4925[a]	4895–4955	3628[a]	3599–3657	2500[a]	2471–2528	1743[a]	1706–1781	5406[a]	5386–5425	9868[a]	9786–9950
V-VD	5012[a]	4973–5051	3832[a]	3798–3866	2563[a]	2534–2593	1916[a]	1883–1949	5932[a]	5911–5952	10,270[a]	10,193–10347
V-NV (control)	5070[a]	5027–5112	3562[a]	3530–3594	1838[c]	1806–1871	2225[c]	2181–2269	7145[c]	7117–7173	12,185[c]	12,074–12296

Different superscripts (a–c) within each column indicate significantly ($P < 0.05$) different values.

* Values are PCV2 antibody titers (ELISA).

of the experiment (week 22). The level of IgG was significantly higher in V-VA, V-VB, V-VC and V-VD groups than for NV (V-NV and NV-NV; weeks 6). The V-NV and NV-NV groups had significantly higher PCV2 antibody titers than V-VA, V-VB, V-VC and V-VD piglets at weeks 10, 15, and 22. Serum IgG antibodies gradually increased in the NV-NV group until week 22.

3.3. PCV2 viremia

No genomic copies of PCV2 were detected in any of the serum samples from vaccinated and non-vaccinated piglets at weeks 1, 3, and 6. NV-NV and V-NV groups had early onset of viremia at week 10 (Table 4). The mean viremia levels of PCV2 DNA increased in all six groups from 10 weeks of age. V-VA, V-VB, V-VC and V-VD pigs had a significantly lower number of genomic copies of PCV2 in serum than for NV ones (NV-NV and the V-NV groups) at weeks 10, 15, and 22 ($P < 0.05$). The peak levels of 64.71% of PCR-positive serum samples from NV-NV pigs were reached at week 22 (Table 4). The percentage of viremic pigs was significantly lower among each group of vaccinated pigs compared to the non-vaccinate ones (NV-NV and V-NV) at weeks 10, 15, and 22 ($P < 0.05$). Moreover, the amount of PCV2 genomic DNA was significantly lower ($P < 0.05$) in V-NV pigs compared with NV-NV group (weeks 10, 15 and 22).

4. Discussion

In the present study, the antibody titers of vaccinated dams were boosted 4- to 5-fold after two vaccinations; in the first week of life, PCV2-specific antibody titers in sera from piglets were very similar to those of their dams, as previously described (Kurmann et al., 2011). Anti-PCV2 IgG antibody titers in vaccinated piglets and V-NV group decreased gradually about 3-fold until the week 10; these results are in agreement with two field studies in which sows were vaccinated with one (Fraile et al., 2012) and three (Kurmann et al., 2011) doses of a commercially available PCV2 vaccine.

A threshold of 10 $\log_2$ has been used to categorize pigs as high, moderate and low MDA titers (Fachinger et al., 2008; Fort et al., 2009a; Haake et al., 2014). In this trial, piglets vaccinated at 3 weeks of age showed high MDA levels ranged from 3628 to 3832. Interference with the efficacy on the PCV2 vaccine depends on the level of MDA at the time of vaccination. Animals with titers equal or beyond 10 $\log_2$ show interference with the development of the humoral immune response after vaccination, while piglets with levels below 8 $\log_2$ do not (Fort et al., 2009a). Therefore, even in the presence of high levels of MDA, piglets immunized with four commercial PCV2 vaccines at 3 weeks, or 3 and 6 weeks post-partum responded to vaccination with a significantly reduced

Table 4.
Mean values of the genomic copy number of porcine circovirus type 2 (PCV2) DNA in serum and percentage of positive samples from vaccinated piglets and unvaccinated and control groups.

Groups	PCV2 genomic copies/ml serum ($\log_{10}$)						Number (%) of positive pigs		
	Week 10		Week 15		Week 22		Week 10	Week 15	Week 22
	Mean	95% CI	Mean	95% CI	Mean	95% CI			
NV-NV	1.11[a]	1.06–1.16	4.23[a]	4.15–4.31	6.47[a]	6.39–6.77	16/51 (31.37%)[a]	28/52 (53.85%)[a]	33/51 (64.71%)[a]
V-VA	0[b]	0	2.53[b]	2.50–2.56	4.64[b]	4.61–4.67	0/50 (0%)[b]	9/51 (17.67%)[b]	15/51 (29.41%)[b]
V-VB	0[b]	0	2.45[b]	2.39–2.51	4.81[b]	4.75–4.87	0/52 (0%)[b]	10/53 (18.87%)[b]	17/52 (32.69%)[b]
V-VC	0[b]	0	2.82[b]	2.76–2.88	4.70[b]	4.64–4.76	0/51 (0%)[b]	11/48 (22.92%)[b]	15/49 (30.61%)[b]
V-VD	0[b]	0	2.80[b]	2.77–2.83	4.80[b]	4.78–4.83	0/53 (0%)[b]	10/50 (20.41%)[b]	17/50 (34.00%)[b]
V-NV (control)	0.46[c]	0.42–0.50	3.60[c]	3.53–3.66	5.67[c]	5.61–5.73	1/53 (1.89%)[b]	22/48 (45.83%)[c]	30/51 (58.82%)[a,c]

Different superscripts (a–c) within each column indicate significantly ($P < 0.05$) different values.

viremia, number of PCV2-positive pigs and mortality rate, and a significantly greater ADWG than those of the V-NV group. This interference involves a number of possible mechanisms, including the neutralization of the vaccine antigens, the masking of B cell epitopes and the inhibition of B cell activation via Fc receptor-mediated signals (Siegrist, 2003; Opriessnig et al., 2010).

The mean $\log_{10}$ viral load in vaccinated piglets (V-VD, Circumvent) was calculated to be 77.78% (15 weeks of age) to 84.66% (22 weeks of age) lower than the control group (V-NV). However, vaccinated piglets showed a reduction in the PCV2 viremia of 50% at 17 weeks of age, compared to the control group (Horlen et al., 2008). A well-documented feature of piglet vacination under field conditions is the ability to diminish the proportion of PCV2-positive pigs and the viral load of infected animal (Fachinger et al., 2008; Kixmöller et al., 2008). In the present study, piglets with maternally derived antibodies and injected with one of four different vaccines, no significant difference in viremia was detected between groups. However, Seo et al. (2014) demonstrated that piglets vaccinated with inactivated chimeric PCV1-2 (Fostera PCV) and inactivated PCV2 (Circovac) resulted in significantly lower viremia compared to subunit vaccines (Circoflex and Porcilis PCV) at 2 and 3 weeks post vacination (Seo et al., 2014).

The optimization of vaccination protocols can contribute to positive production parameters, but limited data are available comparing the effect of the four vaccines on growth performance and mortality rate. Besides this, only four studies into the efficacy of sows and piglets vaccinated have been carried out under experimental (Opriessnig et al., 2010) and field conditions (Pejsak et al., 2010; Fraile et al., 2012; Villa-Mancera et al., 2013). In these studies, a significant effect of sow vaccination on ADWG was found for vaccinated pigs, similar results were obtained in the present study, since ADWG of pigs were significantly higher than the V-NV group.

Other important parameters for evaluating the efficacy of four vaccines under field conditions were mortality rate and viremia load in serum. Under field conditions, the application of PCV2 vaccines have proven to be efficacious at protecting against PMWS development showed that vaccinated pigs had lower mortality rate, thereby reducing the economic impact on affected farms (Horlen et al., 2008; Kixmöller et al., 2008). At the beginning of our study, the farm had a mortality rate of 27.64% during several months. The results show that the vaccination of sows and piglets with any of the four vaccines reduced the overall mortality ranging from 10.82% to 12.79%; the statistically significant differences were related to a decreased number of pigs with PCV2. During the nursery and fattening period (weeks 3–22) V-VC pigs (Circoflex) exhibited a reduced mortality rate of 10.77%, and Fachinger et al., 2008 found a difference in rates of 2.04 between 3 and 25 weeks of age. For V-VD pigs (Circumvent), overall mortality rate was reduced by 60.98%, whilst mortality between the vaccinated and control groups decreased by 50% (Horlen et al., 2008). Vaccinated piglets from vaccinated sows (V-VB, Circovac) showed a significant reduction in mortality rate of 55.44%, this results are in disagreement with a previous report with same PCV2 vaccine (9.33%) (Pejsak et al., 2010).

5. Conclusions

Commercially available PCV2 vaccines vary in the nature of the antigen, adjuvant types, as well in the recommended dosage and administration to animals. However, the four vaccines used in this study, significantly reduced mortality rate and improved ADWG, diminish both the number of PCV2-positive pigs as well as the viral load of infected pigs in the presence of high MDA levels.

Acknowledgements

This study was supported by PRODEP (Programa para el Desarrollo Profesional Docente para el Tipo Superior) and Meritorious Autonomous University of Puebla). This study was supported by PRODEP DSA 103.5/15/7449, Folio BUAP-PTC-410 and DSA/103.5/15/10471, Folio BUAP-PTC-419 (Programa para el Desarrollo Profesional Docente para el Tipo Superior) and Meritorious Autonomous University of Puebla (VIEP-VIMA-NAT-16-I).

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