

Streptococcus suis (Strep suis) prevalence and comparative treatment study

Excede[®] for Swine (ceftiofur crystalline free acid) vs. Baytril[®] (enrofloxacin)

Objective

Understand *Strep suis* diagnostic trends and compare treatment options, Excede for Swine vs. Baytril.

Summary of conclusions

- ✓ *Strep suis* cases have steadily increased since 2013 with a 40% spike in diagnosed cases from 2019 to 2020¹
- ✓ Clinical presentation can vary but that does not impact treatment decisions
- ✓ In a study, Excede for Swine provided better control of secondary *Strep suis* infection compared to Baytril that can translate into substantial savings for producers²

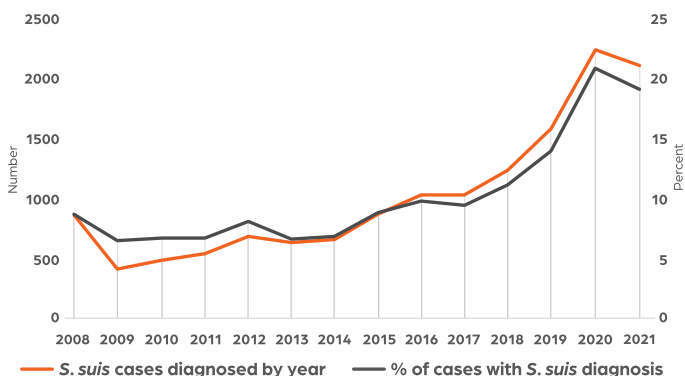
Pigs treated with Excede for Swine experienced lower mortality rates and better control of secondary *Strep suis* infection compared to Baytril²

Background

Strep suis is no stranger to pig operations. The disease has been present almost as long as pigs have been domesticated, with infections recorded on nearly every hog farm.³ Iowa State University Veterinary Diagnostic Laboratory (ISU VDL) trends have shown that diagnosed cases of *Strep suis* increased 116% from 2017 to 2020, with a 40% increase occurring between 2019 and 2020 alone.¹

While pig-to-pig transmission is the most common route of infection, this zoonotic disease can also be introduced to farms by people and fomites. Piglets are most at risk, especially in the nursery when pigs are mixed from different sources. While older pigs (finishers and sows) aren't at as much risk of infection, a challenge can present itself at any time.³

Strep suis Diagnostic Trends at ISU VDL



"We've seen startling increases in *Strep suis* in recent years. In 2020 and 2021, approximately 20% of submitted ISU cases had *Strep suis* present, compared to <10% in 2017."

Dr. Giovani Trevisan, DVM, MBA, PhD
Iowa State University

Although it typically does not impact treatment decisions, the specific *Strep suis* strain and the course traveled by the bacteria, can lead to different clinical presentations:³

- Arthritis (swollen joints and difficulty walking)
- Pneumonia and polyserositis
- Meningitis (neurological signs and brain swelling)
- Septicemia and sudden death

Effective solution to treat *Strep suis*

Although *Strep suis* is on the rise, there are effective solutions to fight this evolving threat. Excede for Swine is a third-generation cephalosporin approved for treatment and control of swine respiratory disease (SRD) associated with *Strep suis*.^{*} In a study, pigs treated with Excede for Swine had significantly less growth of *Strep suis* compared to those treated with enrofloxacin.

Study Design

A total of 140 healthy commercial pigs were divided into seven treatment groups of 20 pigs each. Three groups received one dose of Excede for Swine at either 3, 5 and 7 days before a challenge with *Actinobacillus pleuropneumoniae* (APP), while another three groups received one dose of Baytril at the same schedule of either 3, 5 or 7 days prior to the APP challenge. The last group received saline as a control.⁴

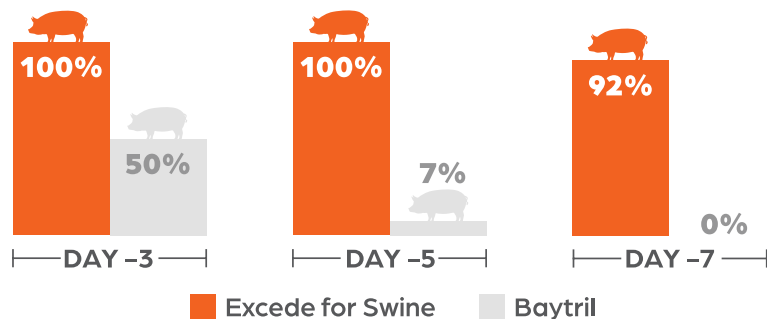
In the same study, researchers also evaluated protection against bacterial growth of *Strep suis* by measuring the bacterial load for each treatment group.

Treatment groups	Days before challenge treatments administered	Number of pigs	Challenge (Day 0)	Study end (Day 5 post-challenge)
Excede for Swine	-3	20	APP serotype 5	Pigs scored for lung lesions
Excede for Swine	-5	20		
Excede for Swine	-7	20		
Baytril	-3	20		
Baytril	-5	20		
Baytril	-7	20		
Saline	-3	20		

Results

Excede for Swine significantly improved survival rate and protected against *Strep suis* for 7 days, outlasting Baytril by at least 4 days.²

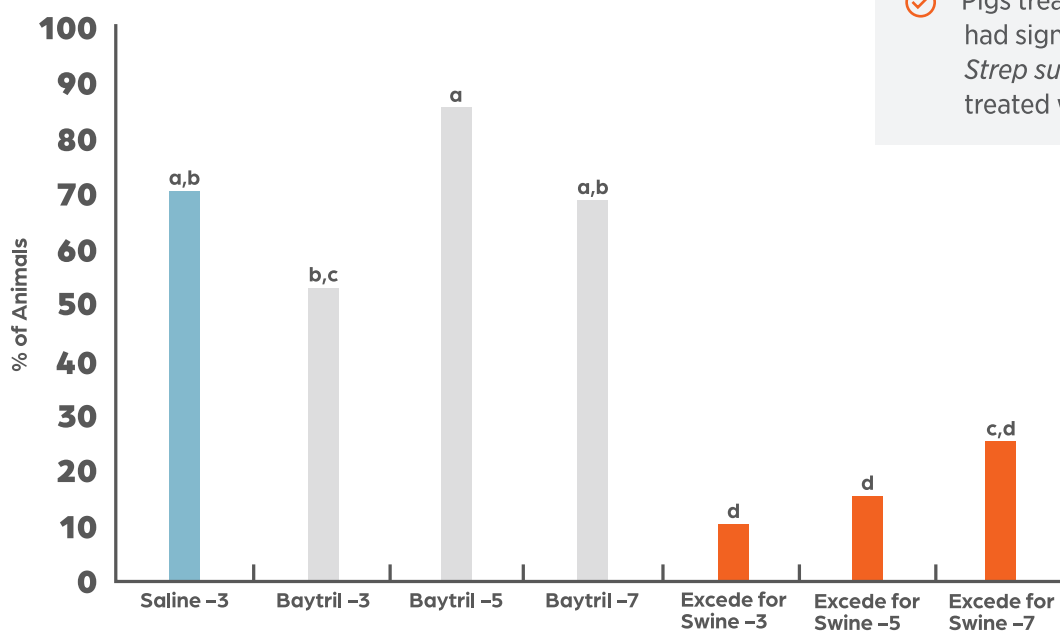
Mortality reduction compared with controls (%)



Key Point

- On day -7, mortality of pigs treated with Excede for Swine decreased by 92% compared to pigs treated with Baytril²

Excede for Swine vs. Baytril comparative study: *Strep suis* isolation



Different superscripts indicate statistical significance ($P < 0.05$).

Key Point

- Pigs treated with Excede for Swine had significantly less growth of *Strep suis* compared to those treated with Baytril²

For more information, talk to your Zoetis representative or visit ZoetisUS.com/ExcedeforSwine.

IMPORTANT SAFETY INFORMATION: People with known hypersensitivity to penicillin or cephalosporins should avoid exposure to Excede for Swine. Do not use in swine found to be hypersensitive to the product. Pre-slaughter withdrawal time is 14 days following the last dose. See full Prescribing Information, attached.

*Indicated for the treatment and control of SRD associated with *Actinobacillus pleuropneumoniae*, *Pasteurella multocida*, *Haemophilus parasuis*, and *Streptococcus suis* in groups of pigs where SRD has been diagnosed.

¹Iowa State University. Swine Disease Detection Dashboards. <https://fieldepi.research.cvm.iastate.edu/>.

Accessed November 22, 2022. <https://fieldepi.research.cvm.iastate.edu/domestic-swine-disease-monitoring-program/>

²Data on file, Study Report No. ORPORK 2030, Zoetis LLC.

³Gottschalk M et al. "Chapter 61: Streptococcosis" Diseases of Swine, 11th edition, Wiley-Blackwell, April 2019, p 934-950.

⁴Data on file, Study Protocol No. ORPORK 2030, Zoetis LLC.

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EXCEDE[®] FOR SWINE

(Ceftiofur Crystalline Free Acid)
Sterile Suspension 100 mg/mL

For intramuscular administration in the post-auricular region of the neck of swine.

CAUTION

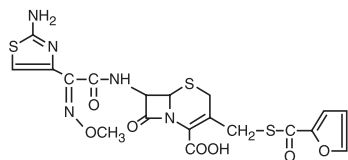
Federal (USA) law restricts this drug to use by or on the order of a licensed veterinarian. Federal law prohibits extra-label use of this drug in swine for disease prevention purposes; at unapproved doses, frequencies, durations, or routes of administration; and in unapproved major food producing species/production classes.

DESCRIPTION

EXCEDE FOR SWINE Sterile Suspension 100 mg/mL is a ready-to-use formulation that contains the crystalline free acid of ceftiofur, which is a broad spectrum cephalosporin antibiotic active against gram-positive and gram-negative bacteria including β -lactamase-producing strains. Like other cephalosporins, ceftiofur is bactericidal *in vitro*, resulting from inhibition of cell wall synthesis.

Each mL of this ready-to-use sterile suspension contains ceftiofur crystalline free acid equivalent to 100 mg ceftiofur, in a Caprylic/capric triglyceride and cottonseed oil based suspension.

Figure 1. Structure of ceftiofur crystalline free acid:



Chemical name of ceftiofur crystalline free acid:

7-[[2-(2-Amino-4-thiazolyl)-2-(methoxyimino)acetyl]amino]-3-[[[2-(furanylcarbonyl)thio]methyl]-8-oxo-5-thia-1-azabicyclo[4.2.0]oct-2-ene-2-carboxylic acid

INDICATIONS

EXCEDE FOR SWINE Sterile Suspension 100 mg/mL is indicated for the treatment of swine respiratory disease (SRD) associated with *Actinobacillus pleuropneumoniae*, *Pasteurella multocida*, *Haemophilus parasuis*, and *Streptococcus suis*; and for the control of SRD associated with *Actinobacillus pleuropneumoniae*, *Pasteurella multocida*, *Haemophilus parasuis*, and *Streptococcus suis* in groups of pigs where SRD has been diagnosed.

DOSAGE

Administer by intramuscular (IM) injection in the post-auricular region of the neck as a single dosage of 2.27 mg ceftiofur equivalents (CE)/lb (5.0 mg CE/kg) body weight (BW). This is equivalent to 1 mL sterile suspension per 44 lb (20 kg) BW. No more than 2 mL should be injected in a single injection site. Injection volumes in excess of 2 mL per injection site may result in violative residues. Pigs heavier than 88 lb (40 kg) will require more than one injection.

Most animals will respond to treatment within three to five days. If no improvement is observed, the diagnosis should be re-evaluated.

ADMINISTRATION

Shake well before using. EXCEDE FOR SWINE Sterile Suspension 100 mg/mL is to be administered by intramuscular injection in the post-auricular region of the neck.

CONTRAINDICATIONS

As with all drugs, the use of EXCEDE FOR SWINE Sterile Suspension 100 mg/mL is contraindicated in animals previously found to be hypersensitive to the drug.

WARNINGS

FOR USE IN ANIMALS ONLY.

NOT FOR HUMAN USE. KEEP OUT OF REACH OF CHILDREN.

Penicillins and cephalosporins can cause allergic reactions in sensitized individuals. Topical exposures to such antimicrobials, including ceftiofur, may elicit mild to severe allergic reactions in some individuals. Repeated or prolonged exposure may lead to sensitization. Avoid direct contact of the product with the skin, eyes, mouth and clothing. Sensitization of the skin may be avoided by wearing protective gloves.

Persons with a known hypersensitivity to penicillin or cephalosporins should avoid exposure to this product.

In case of accidental eye exposure, flush with water for 15 minutes. In case of accidental skin exposure, wash with soap and water. Remove contaminated clothing. If allergic reaction occurs (e.g., skin rash, hives, difficult breathing), seek medical attention.

The material safety data sheet contains more detailed occupational safety information. To report adverse effects in users, to obtain more information or to obtain a material safety data sheet, call 1-888-963-8471.

RESIDUE WARNINGS

- A maximum of 2 mL of formulation should be injected at each injection site. Injection volumes in excess of 2 mL per injection site may result in violative residues.
- Following label use as a single treatment, a 14-day pre-slaughter withdrawal period is required.
- **Use of dosages in excess of 5.0 mg ceftiofur equivalents (CE)/kg or administration by an unapproved route may result in illegal residues in edible tissues.**

PRECAUTIONS

The safety of ceftiofur has not been demonstrated for pregnant swine or swine intended for breeding. Administration of EXCEDE FOR SWINE Sterile Suspension 100 mg/mL as directed may induce a transient reaction at the site of injection and underlying tissues that may result in trim loss of edible tissue at slaughter.

ADVERSE REACTIONS

An injection site tolerance study demonstrated that EXCEDE FOR SWINE Sterile Suspension 100 mg/mL is well tolerated in pigs. Half of the injection sites at both 3 and 7 days post-injection were scored as "negative" for irritation and the other half were scored as "slight irritation". All gross observations and measurements of injection sites qualified the sites at 10 days post-injection as "negative" for irritation.

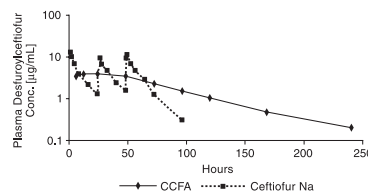
No adverse effects were observed in multi-location field efficacy studies involving more than 1000 pigs.

CLINICAL PHARMACOLOGY

Ceftiofur administered as either ceftiofur sodium (NAXCEL[®] Sterile Powder), ceftiofur hydrochloride (EXCENEL[®] RTU Sterile Suspension) or ceftiofur crystalline free acid (EXCEDE FOR SWINE Sterile Suspension 100 mg/mL) is metabolized rapidly to desfuroylceftiofur, the primary metabolite. Administration of ceftiofur to swine as ceftiofur crystalline free acid (CCFA) at a single IM dosage of 2.27 mg CE/lb (5.0 mg CE/kg) BW provides concentrations of ceftiofur and desfuroylceftiofur-related metabolites in plasma that are multiples above the MIC₉₀* for the SRD label pathogens *Actinobacillus pleuropneumoniae*, *Pasteurella multocida*, *Haemophilus parasuis* and *Streptococcus suis* for an extended period of time (see Figure 2 and Tables 1–2).

The average plasma concentrations of ceftiofur- and desfuroylceftiofur-related metabolites for CCFA (EXCEDE FOR SWINE Sterile Suspension 100 mg/mL) after IM administration of 2.27 mg CE/lb (5.0 mg CE/kg) BW and those for ceftiofur sodium (NAXCEL Sterile Powder) after IM administration at 1.36 mg CE/lb (3 mg CE/kg) BW for three consecutive days are presented in Figure 2 below.

Figure 2. Average plasma concentrations of ceftiofur- and desfuroylceftiofur-related metabolites for CCFA (EXCEDE FOR SWINE Sterile Suspension 100 mg/mL) after IM administration of 2.27 mg CE/lb (5.0 mg CE/kg) BW and those for ceftiofur sodium (NAXCEL Sterile Powder) after IM administration at 1.36 mg CE/lb (3 mg CE/kg) BW for three consecutive days



Pharmacokinetic parameters measured after a single IM administration of 2.27 mg CE/lb (5.0 mg CE/kg) BW of EXCEDE FOR SWINE Sterile Suspension 100 mg/mL in the post-auricular region of the neck of swine are presented in the following table (Table 1).

* Minimum inhibitory concentration for 90% of the isolates

Table 1. Pharmacokinetic parameters in swine after a single IM administration of EXCEDE FOR SWINE Sterile Suspension 100 mg/mL at 2.27 mg CE/lb (5.0 mg CE/kg) BW

Pharmacokinetic Parameter	Mean Value ± Standard Deviation (non-compartmental analyses)
C _{max} (µg/mL)	4.17 ± 0.92
t _{max} (h)	22.0 ± 12.2
AUC ₀₋₁₀₀ (µg•h/mL)	373.0 ± 56.1
t _{1/2} (h)	49.6 ± 11.8

C_{max} = maximum plasma concentration (in µg CE/mL)

t_{max} = the time after injection when C_{max} occurs (in hours)

AUC₀₋₁₀₀ = the area under the plasma concentration vs. time curve from time of injection to the limit of quantitation of the assay (0.15 µg CE/mL)

t_{1/2} = terminal phase biological half-life (in hours)

Table 2. Ceftiofur minimum inhibitory concentration (MIC) values* of indicated pathogens isolated from SRD treatment and control field studies conducted in the U.S.

Indicated Pathogens	Year(s) of Isolation	Field Study	Number of Isolates	MIC ₅₀ ** (µg/mL)	MIC ₉₀ ** (µg/mL)	MIC Range (µg/mL)
<i>Actinobacillus pleuropneumoniae</i>	2000 to 2001	Treatment	5	NA	NA	≤0.03 to 0.06
	2009	Control	34	0.03	0.06	0.015 to 0.06
<i>Pasteurella multocida</i>	2000 to 2001	Treatment	20	≤0.03	≤0.03	≤0.03†
	2009	Control	67	≤0.004	≤0.004	≤0.004†
<i>Streptococcus suis</i>	2000 to 2001	Treatment	30	0.06	0.12	≤0.03 to 0.5
	2009	Control	141	0.25	1	0.03 to >2

* The correlation between *in vitro* susceptibility data and clinical effectiveness is unknown.

** The lowest MIC to encompass 50% and 90% of the most susceptible isolates, respectively.

† No range; all isolates yielded the same value.

MICROBIOLOGY

Ceftiofur has demonstrated *in vitro* activity against *Actinobacillus pleuropneumoniae*, *Pasteurella multocida*, *Haemophilus parasuis*, and *Streptococcus suis*, four major pathogenic bacteria associated with SRD.

The minimum inhibitory concentrations (MICs) of ceftiofur against indicated SRD pathogens were determined using methods recommended by the Clinical and Laboratory Standards Institute (CLSI) using the M31-A and M31-A3 standards for the SRD treatment (2000-2001) and control (2009) studies, respectively. Isolates from the SRD treatment study were obtained from lung tissue collected from non-treated pigs prior to enrollment and saline-treated pigs that died or were euthanized during the study. Isolates from the SRD control study were obtained from lung tissue from non-treated pigs euthanized prior to enrollment and from saline- and ceftiofur-treated pigs that died or were euthanized during the study. The susceptibility results for the treatment and control studies are presented in Table 2.

Based on pharmacokinetic data from studies of ceftiofur in swine after a single intramuscular injection of 2.27 mg CE/lb (5.0 mg CE/kg) BW, the following interpretive criteria are recommended by CLSI:

Table 3. CLSI-accepted interpretive criteria for ceftiofur against swine respiratory disease pathogens*

Pathogens	Disk Potency	Zone Diameter (mm)	MIC (µg/mL)	Interpretation
<i>Actinobacillus pleuropneumoniae</i>	30 µg	≥21	≤2.0	(S) Susceptible
<i>Pasteurella multocida</i>		18-20	4.0	(I) Intermediate
<i>Streptococcus suis</i>		≤17	≥8.0	(R) Resistant

* These interpretive criteria should only be used when the CLSI M31-A3 performance standard is used to determine antimicrobial susceptibility to ceftiofur.

EFFECTIVENESS

The effectiveness of a single dose of 2.27 or 3.18 mg CE/lb BW (5.0 or 7.0 mg CE/kg BW) EXCEDE FOR SWINE Sterile Suspension 100 mg/mL for the treatment of SRD was confirmed in a well-controlled, multi-location field study. A total of 706 pigs with clinical signs of bacterial respiratory disease were enrolled and treated with a placebo injection or EXCEDE FOR SWINE Sterile Suspension 100 mg/mL administered as a single IM injection in the post-auricular region of the neck. Clinical observations were performed on Days 1-7 and rectal temperatures were taken on Days 1, 3, and 6 following treatment (Day 0). Necropsies were performed on all pigs that died during the study and after euthanasia of all remaining study pigs at the end of the 14-day post-enrollment study period. Lung lesions were scored and lungs were submitted for bacterial identification. Mortality rates were numerically lower (but not statistically different) for the EXCEDE FOR SWINE Sterile Suspension 100 mg/mL-treated groups (4.3% for the 5.0 mg CE/kg BW group and 4.2% for the 7.0 mg CE/kg BW group) compared with the placebo-treated control group (6.3%). There was a statistically significant ($p < 0.05$) improvement in clinical cure rates for the EXCEDE FOR SWINE Sterile Suspension 100 mg/mL-treated groups (24.8% for the 5.0 mg CE/kg BW group and 26.4% for the 7.0 mg CE/kg BW group) compared with the placebo-treated control group (17.7%). Lung lesion scores were numerically higher (but not statistically different) for the EXCEDE FOR SWINE Sterile Suspension 100 mg/mL-treated groups (10.4% for both the 5.0 mg CE/kg BW and the 7.0 mg CE/kg BW group) compared with the placebo-treated control group (9.2%). Bacteriological culture of the lungs of study pigs identified the following respiratory pathogens: *Actinobacillus pleuropneumoniae*, *Pasteurella multocida*, *Haemophilus parasuis*, and *Streptococcus suis*.

The effectiveness of a single dose of 2.27 CE/lb BW (5.0 mg CE/kg BW) EXCEDE FOR SWINE for the control of SRD was evaluated in a multi-location natural infection field study. At each site, when at least 15% of the study candidates in a pen showed clinical signs of SRD, all pigs in the pen were enrolled and treated with EXCEDE FOR SWINE (n = 346) or saline (n = 347). Responses to treatment were evaluated 7 days post-treatment. Success was defined as a pig that survived to Day 7 and had normal attitude, normal respiration, and a rectal temperature of $< 104^{\circ}\text{F}$. The treatment success rate was significantly higher ($p = 0.0188$) for EXCEDE FOR SWINE-treated pigs (59.6%) compared to the saline-treated pigs (41.4%). Bacteriological culture of the lungs of study pigs identified the following respiratory pathogens: *Actinobacillus pleuropneumoniae*, *Pasteurella multocida*, *Haemophilus parasuis*, and *Streptococcus suis*.

Table 4. Acceptable quality control ranges for ceftiofur against CLSI recommended American Type Culture Collection (ATCC) reference strains

Organism Name (ATCC No.)	MIC (µg/mL)	Zone Diameter, mm (Disk Content 30 µg)
<i>E. coli</i> ATCC 25922	0.25–1.0	26–31
<i>S. aureus</i> ATCC 29213	0.25–1.0	—
<i>S. aureus</i> ATCC 25923	—	27–31
<i>P. aeruginosa</i> ATCC 27853	16.0–64.0	14–18

ANIMAL SAFETY

After parenteral administration, CCFA, ceftiofur sodium, and ceftiofur hydrochloride are metabolized to the same principal metabolite, desfuroylceftiofur. Plasma levels achieved are similar after recommended dosing (Figure 2). Therefore, studies conducted with ceftiofur sodium are adequate to evaluate the systemic safety of CCFA. Results from a five-day tolerance study in normal feeder pigs indicated that ceftiofur sodium produced no overt adverse signs of toxicity and was well tolerated when administered at 57 mg CE/lb (125 mg/kg) BW (more than 25 times the recommended dosage of CCFA) for five consecutive days. An additional dose toxicity study was conducted to determine the safety margin of ceftiofur in swine. Five barrows and five gilts per group were administered ceftiofur sodium IM at 0, 2.27, 6.81 and 11.36 mg CE/lb (0, 5, 15, 25 mg CE/kg) BW (0, 1, 3 and 5 times the recommended dosage for CCFA) for 15 consecutive days. There were no adverse systemic effects observed, indicating that ceftiofur sodium has a wide margin of safety when administered intramuscularly in feeder pigs.

A separate study evaluated the injection site tissue tolerance of EXCEDE FOR SWINE Sterile Suspension 100 mg/mL in swine when administered intramuscularly as a single injection at the maximum recommended dose volume of 2 mL (approximately 5 mg CE/kg BW) per injection site. Because injection site volumes greater than 2 mL may result in violative residues, only injection volumes of 2 mL were evaluated in this study. EXCEDE FOR SWINE Sterile Suspension 100 mg/mL was injected intramuscularly into each side of the neck of six swine at a dose volume of 2 mL/injection site. Clinical observations were made daily. At 3, 7 and 10 days post-injection, pairs of animals were euthanized and the neck injection sites were dissected for pathological examination (4 injection sites per time point). The injections were well tolerated in all pigs. Clinically, injection site reactions ranged from nondetectable (6 of 12 sites) to a transitory (up to 4 days post-injection) palpable, nonvisible swelling (2 of 12 sites) or a small, visible, reddened nodule at the needle insertion point (4 of 12 sites; 3 of 4 nodules were barely detectable by 3 to 7 days post-injection). There was no clinical evidence of the injections at 10 days post-injection. At necropsy, half of the injection sites at both 3 and 7 days post-injection were scored as “negative” for irritation and the other half were scored as “slight irritation”. One animal had a visible lesion described as an area of tan with red speckles present in the deep muscle fascia, less than 6 cm², at 10 days post-injection; this lesion and the remaining injection sites evaluated at 10 days post-injection were scored as “negative” for irritation.

STORAGE CONDITIONS

Store at controlled room temperature 20° to 25°C (68° to 77°F). Shake well before using. Contents should be used within 12 weeks after the first dose is removed.

HOW SUPPLIED

EXCEDE FOR SWINE Sterile Suspension 100 mg/mL is available in the following package size:
100 mL vial

Approved by FDA under NADA # 141-235



Distributed by:
Zoetis Inc.
Kalamazoo, MI 49007

www.excede.com or call 1-888-963-8471

Revised: November 2018

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