

# JOURNAL OF **SWINE** HEALTH & PRODUCTION

Spray-dried bovine plasma in  
PRRSV-positive pigs

*Crenshaw JD, Campbell JM, Polo J, et al*

PRRSV transmission at lairage

*Lowe J, McCann R, Greiner L*

Effects of MLV PRRS vaccines on  
pig performance

*Kang I, Kang HS, Jeong J, et al*

Practice tips: high-fiber withdrawal  
and marketing heavy-weight pigs

*Gonçalves MAD, Dritz SS, Tokach MD, et al*



# Journal of Swine Health and Production

(ISSN 1537-209X) Volume 25, Number 1; January and February 2017  
Copyright © 2017 American Association of Swine Veterinarians



The *Journal of Swine Health and Production* is published by the American Association of Swine Veterinarians.

Opinions expressed in this publication are those of the individual authors and do not necessarily reflect the endorsement, official attitude, or position of the American Association of Swine Veterinarians, the *Journal of Swine Health and Production*, or any Industry Support Council member.

The *Journal of Swine Health and Production* is a refereed publication and is a benefit of membership in the American Association of Swine Veterinarians. Subscriptions (\$US) are available to nonmembers at \$145.00 per year (six issues) for United States, Canada, and Mexico. The cost is \$180.00 for all countries outside North America. For inquiries regarding membership or subscriptions, please contact

AASV  
830 26<sup>th</sup> Street, Perry, IA 50220-2328  
Tel: 515-465-5255; Fax: 515-465-3832  
E-mail: [aasv@aasv.org](mailto:aasv@aasv.org)

Editorial questions, comments, and inquiries should be addressed to Karen Richardson, Publications Manager:  
Tel: 519-856-2089; Fax: 519-763-3117;  
E-mail: [pub\\_mgr@aasv.org](mailto:pub_mgr@aasv.org)

## DISCLAIMER

Scientific manuscripts published in the *Journal of Swine Health and Production* are peer reviewed. However, information on medications, feed, and management techniques may be specific to the research or commercial situation presented in the manuscript. It is the responsibility of the reader to use information responsibly and in accordance with the rules and regulations governing research or the practice of veterinary medicine in their country or region.

## AASV Officers

**GEORGE CHARBONNEAU**  
President,  
[gcharbonneau@southwestvets.ca](mailto:gcharbonneau@southwestvets.ca)

**ALEX RAMIREZ**  
President-elect,  
[ramireza@iastate.edu](mailto:ramireza@iastate.edu)

## AASV Staff

**TOM BURKGREN**  
Executive Director,  
[burkgren@aasv.org](mailto:burkgren@aasv.org)

**SUE SCHULTEIS**  
Associate Director,  
[aasv@aasv.org](mailto:aasv@aasv.org)

## JSHAP Staff

**TERRI O'SULLIVAN**  
Executive Editor, [pub\\_mgr@aasv.org](mailto:pub_mgr@aasv.org)

**JUDI BELL**  
Associate Editor, [pub\\_mgr@aasv.org](mailto:pub_mgr@aasv.org)

**KAREN RICHARDSON**  
Publications Manager, [pub\\_mgr@aasv.org](mailto:pub_mgr@aasv.org)

**TINA SMITH**  
Graphic Designer, Advertising Coordinator,  
[tina@aasv.org](mailto:tina@aasv.org)

## Editorial Board

**GLEN ALMOND**  
North Carolina, [glen\\_almond@ncsu.edu](mailto:glen_almond@ncsu.edu)

**JANE CHRISTOPHER-HENNINGS**  
South Dakota, [Jane.Hennings@sdstate.edu](mailto:Jane.Hennings@sdstate.edu)

**JOHN HARDING**  
Saskatchewan, [john.harding@usask.ca](mailto:john.harding@usask.ca)

**JAMES KOBER**  
Michigan, [svsmi@sbcglobal.net](mailto:svsmi@sbcglobal.net)

**DARIN MADSON**  
Iowa, [madson@iastate.edu](mailto:madson@iastate.edu)

**ADAM MOESER**  
Michigan, [moeserad@cvm.msu.edu](mailto:moeserad@cvm.msu.edu)

**SCANLON DANIELS**  
Vice President,  
[scanlon@circleh.info](mailto:scanlon@circleh.info)

**RON BRODERSON**  
Immediate Past President,  
[ronb@wholehogai.com](mailto:ronb@wholehogai.com)

**HARRY SNELSON**  
Director of Communications,  
[snelson@aasv.org](mailto:snelson@aasv.org)

**DAVE BROWN**  
Webmaster/IT Specialist,  
[dave@aasv.org](mailto:dave@aasv.org)

**LAURA BATISTA AND SANDRA PÉREZ**  
Spanish translators

**SERGE MESSIER**  
French translator

**ZVONIMIR POLJAK**  
Consulting Epidemiologist

**THOMAS PARSONS**  
Pennsylvania, [thd@vet.upenn.edu](mailto:thd@vet.upenn.edu)

**ALEX RAMIREZ**  
Iowa, [ramireza@iastate.edu](mailto:ramireza@iastate.edu)

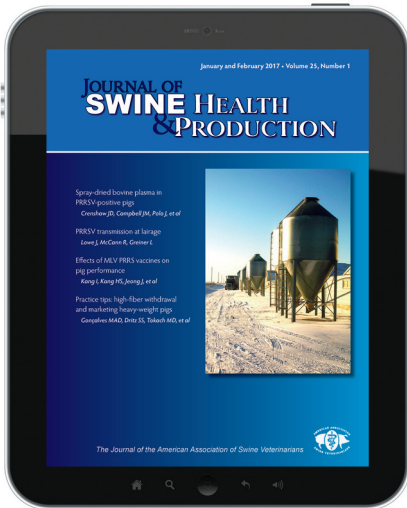
**MIKE TOKACH**  
Kansas, [mtokach@ksu.edu](mailto:mtokach@ksu.edu)

**BETH YOUNG**  
Sweden, [byoung.dvm@gmail.com](mailto:byoung.dvm@gmail.com)

**JEFF ZIMMERMAN**  
Iowa, [jjzimm@iastate.edu](mailto:jjzimm@iastate.edu)

*Journal of Swine Health and Production* is indexed in ISI<sup>®</sup> Focus On: *Veterinary Science & Medicine*<sup>®</sup> and in *CAB Abstracts*, Euroscience VETLINE on CD-ROM

# TABLE OF CONTENTS



Download this issue to your iPad or Android tablet at <https://www.aasv.org/shap/issues/v25n1/v25n1jshap.pdf>



## About the cover...

Bright winter day at an Iowa swine facility

*Photo courtesy of Dr John Waddell*

**AASV Resources online at**  
<https://www.aasv.org>

**Author guidelines**  
<https://www.aasv.org/shap/guidelines.pdf>

**Journal of Swine Health and Production**  
<https://www.aasv.org/shap.html>

**Membership information**  
<https://www.aasv.org/aasv/membership.html>

**Subscription information**  
<http://ecom.aasv.org/journal>

**Upcoming meetings**  
<https://www.aasv.org/meetings>

President's message .....	5
Executive Director's message .....	7
Executive Editor's message .....	9
Effects of a nursery feed regimen with spray-dried bovine plasma on performance and mortality of weaned pigs positive for porcine reproductive and respiratory syndrome virus .....	10
<i>Crenshaw JD, Campbell JM, Polo J, et al</i>	
Factors that influence mechanical transmission of porcine reproductive and respiratory syndrome virus at the time of unloading animals into slaughter plant lairage .....	19
<i>Lowe J, McCann R, Greiner L</i>	
Comparison of growth performance under field conditions in growing pigs each vaccinated with one of two commercial modified-live porcine reproductive and respiratory syndrome vaccines .....	24
<i>Kang I, Kang HS, Jeong J, et al</i>	
Fact sheets – considerations regarding marketing heavy-weight pigs, and high-fiber ingredient withdrawal strategy before slaughter in finishing pigs .....	29
<i>Gonçalves MAD, Dritz SS, Tokach MD, et al</i>	
News from the National Pork Board .....	35
AASV news .....	39
AASV Foundation news .....	43
Advocacy in action .....	45
Vice-presidential candidates' messages .....	48
Author guidelines .....	50
Upcoming meetings .....	51

“...it may have slipped your mind that the revised regulations governing the Veterinary Feed Directive (VFD) have now taken full effect.”

*quoted from Advocacy in action, page 45*



**NEW**  
250 mL vial

## Fewer vials. Higher efficiency.

Save labor, time, and hassle with our new 250 mL vial.  
The first and only injectable iron to be offered in this size.



### NATURAL FORMULA

Uniferon<sup>®</sup> 200 is a strongly bound iron complex manufactured without the use of organic solvents or cyanide, avoiding trace residues of these components.



### GLOBAL APPROVAL

Uniferon<sup>®</sup> 200 is the only injectable iron for baby pigs approved by the medical authorities in Europe, Asia and by the Food and Drug Administration (FDA) in the US.



### HUMAN STANDARDS

Uniferon<sup>®</sup> 200 has a good safety profile and is manufactured to the same standards as those required for human medicine.



Uniferon<sup>®</sup>  
The world's #1  
injectable iron



Quality iron for your baby pigs

Uniferon<sup>®</sup> is a registered trademark of Pharmacosmos A/S

T: 908-769-7045

E: [uniferon.us@pharmacosmos.com](mailto:uniferon.us@pharmacosmos.com)

[us.uniferon.com](http://us.uniferon.com)



## Mental health: It's a marathon, not a sprint!

Dr Allen Leman reminded us in his 1988 Kernkamp Lecture<sup>1</sup> that livestock producers want veterinarians, among other things, “to be co-responsible for farm success or failure” and to “help share the burden or worry.” The stakes have always been high for livestock producers. It is a vocation that is not for the risk averse. As farming operations get larger, the potential emotional investment by both the farmer and the farm veterinarian can become substantial.

Dr Andria Jones-Bitton, a veterinary epidemiologist who has recently focused on the issue of veterinary wellness, soon realized from her investigations that farmers were also showing significant evidence of stress.<sup>2</sup> A survey of over 1100 Canadian farmers about stress, anxiety, depression, burnout, and resilience found that 45% are facing high levels of stress, 60% are dealing with some level of anxiety, 35% are dealing with depression, and 35% to 45% are demonstrating signs of burnout. Many food-animal producers grew up believing that agriculture was a higher calling. Unfortunately, these same producers are now deluged with criticism about who they are and what they do. Social media has made it possible for anyone to share their thoughts about food-animal production, with little evidence that these

critics let facts and science get in the way of expressing their opinions. Farmers are under a great deal of stress, and some of that is bound to spill over to the veterinarians attending their farms. This is especially true for those aspiring to help “share the burden or worry.”

Our compassion for our clients and for the pigs in our care motivates us to relieve human and animal suffering. Problems may be quickly resolved or may become protracted. Some events may be traumatic. A mass euthanasia event related to a barn fire or a foreign animal disease incursion can have long-lasting effects on our mental health. Repeated exposure to these traumatic events can produce emotional fatigue and burnout.

*“Farmers are under a great deal of stress, and some of that is bound to spill over to the veterinarians attending their farms.”*

When emotional fatigue sets in, it becomes extremely difficult for a veterinarian to function properly. It can be more difficult to be empathetic. Communication becomes a challenge. The physical effects of emotional fatigue can include headaches and tiredness. These problems can make it almost impossible to deliver the quality of care that we normally aspire to. Brenda Lovell, an independent researcher studying the wellness of veterinarians, has recently shown<sup>3</sup> that work-life balance, emotional demands, and business management are other common sources of stress for veterinarians.

New regulations are changing the role of veterinarians on the farm. As part of the focus on antimicrobial stewardship, veterinarians are being charged with the responsibility to authorize the use of antimicrobials. Along with this authority comes a new level of transparency and accountability. Veterinarians will surely be faced with some complicated ethical dilemmas in balancing antimicrobial stewardship and the need to alleviate animal suffering. We should not be alone in working through these complicated deliberations.

As veterinarians, we need to be armed with the skills needed to cope with these stresses. Steven Covey proposed “Sharpening the Saw<sup>4</sup>” as the 7<sup>th</sup> habit of highly effective people. This involves having an ongoing, balanced program for self-renewal in four key areas: physical, social-emotional, mental, and spiritual. The bottom line is that we will need to devote some time and effort to educating ourselves about better ways to manage stress and emotional fatigue. If we want to be there for our clients and patients, we will first need to be there for ourselves. After all, a career in veterinary medicine is a marathon, not a sprint. We need to do the right training to be able to go the distance!

### References

1. Leman AD. The Diagnosis and Treatment of Food Animal Educational Diseases: HCH Kernkamp Memorial Lecture. *Proc Swine Herd Health Programming Conf.* 1988:232–239.
- \*2. Jones-Bitton A. Farmers relieved mental health issues on the table. Available at <https://www.realagriculture.com/2016/01/farmers-relieved-mental-health-issues-on-the-table-coordinator/>. Accessed 12 November 2016.
3. Lovell BL, Lee RT. Burnout and health promotion in veterinary medicine. *Can Vet J.* 2013;54:790–791.
4. Covey SR. *The 7 Habits of Highly Effective People: Restoring the Character Ethic.* New York: Free Press; 2004.

\* Non-refereed reference.

George Charbonneau, DVM  
AASV President



# Deliberately<sup>™</sup> Different

Accelerated Hydrogen Peroxide<sup>®</sup>  
Disinfectants for Infection Control  
& Biosecurity



## Outbreaks eroding your bottom line? It's time for an **INTERvention**<sup>®</sup>

Accelerated Hydrogen Peroxide<sup>®</sup> (AHP<sup>®</sup>) disinfectants are a *Deliberately Different* way to protect you against the devastating financial impact of an outbreak. Intervention<sup>™</sup> was designed to break the chain of infection before the outbreak starts while remaining less toxic (requiring no PPE at in use solutions) and easy to handle (reducing labour costs). Using Intervention<sup>™</sup> improves animal and human health by reducing the risk of exposure to both harsh chemicals and deadly pathogens.

That's why we are not just **different** from what you're currently using, we are **Deliberately Different**<sup>™</sup>.



[ViroxAnimalHealth.com](http://ViroxAnimalHealth.com)

Contact Virox Animal Health for product distribution information.



Member of the  
AASV Industry Support Council



## Smell test

**Y**ou are familiar with the saying “Does it pass the smell test?” According to Wiktionary, this phrase is defined as “An informal method for determining whether something is authentic, credible, or ethical, by using one’s common sense or sense of propriety.”<sup>1</sup> Given the changes we are about to see in the US concerning the new Veterinary Feed Directive (VFD) regulations, perhaps veterinarians need to apply the smell test to our relationships with our clients. Are we positioning our professional services to maximize these relationships or merely meet a regulatory requirement?

For years the AASV has supported a position that veterinarians should be involved in the decision-making process whenever antibiotics are used. Prior to January 1, 2017, producers did not need a VFD or a veterinarian to include over-the-counter (OTC) antibiotics in feed. With the addition of a requirement for a Veterinarian-Client-Patient Relationship (VCPR) for a lawful VFD when using antibiotics of importance to humans, veterinarians are being given an increased role in decision-making on

antibiotic use in the feed. How we use this opportunity may ultimately determine how we impact swine health and well-being in the future.

---

*“We have an opportunity to demonstrate that veterinary oversight is not just a regulatory requirement. We can show that it benefits animal health and well-being as well as producers’ profitability.”*

---

The Food and Drug Administration has defined these key elements of a VCPR:

1. The veterinarian engages with the client (ie, the animal producer) to assume responsibility for making clinical judgments about patient (ie, animal) health,
2. The veterinarian has sufficient knowledge of the patient by virtue of patient examination and (or) visits to the facility where the patient is managed, and
3. The veterinarian provides for any necessary follow-up evaluation or care.

Given the wording of these elements, it’s clear that farm visits will be needed to establish a VCPR for food animals. The frequency of these visits is dependent on the

professional judgement of the veterinarian. Here is where we need to apply the smell test. A farm visit by a veterinarian for the sole purpose of meeting a regulatory requirement may not pass the smell test. Such a “windshield” practice may check the box of a VCPR, but one’s common sense should take issue with this approach. Only through a thorough understanding of the care and keeping of animals, along with clinical examination and history, diagnostic testing, and record examination, can the value of a veterinarian’s relationship with a client and pigs be fully recognized.

There may be some angst among farmers now facing increased veterinarian involvement. I acknowledge that change can be hard, but we can choose to maintain some façade that veterinary oversight is present or we can seize this opportunity to demonstrate the value of a veterinarian and a working relationship with the people and pigs we are here to serve. We have an opportunity to demonstrate that veterinary oversight is not just a regulatory requirement. We can show that it benefits animal health and well-being as well as producers’ profitability. Ultimately we can ensure that no matter who is sniffing around, we can pass the smell test.

## References

1. Wiktionary. Smell test. Available at [https://en.wiktionary.org/wiki/smell\\_test](https://en.wiktionary.org/wiki/smell_test). Accessed 18 November 2016.

Tom Burkgren, DVM  
Executive Director



# Proven Dewormer

**Safe-guard®**  
(Active ingredient Fenbendazole 1.8% (8.172 g/lb.))

# EZ-Scoop®

MEDICATED DEWORMER FOR SWINE  
Type B Medicated Feed



**Safe-guard® EZ-Scoop® is now available from Provimi®**

## Unique Protection

- Kills not only adult worms, but also the important larvae, including tunneling L2 and L3 whipworm and migrating L3 roundworm larvae.
- Flexible feeding schedule over a 3- to 12-day period.
- Easy convenient individual sow daily dosing.
- Proven efficacy in a single wormer.



For more information call:  
**937-770-2423**

**F100012055 SAFE-GUARD® EZ-SCOOP® 1.8%  
10 lb pail**

Consult your veterinarian for assistance in the diagnosis, treatment and control of parasitism.



## Reflection

Happy New Year! It feels like just last week that I was writing my message for the January 2016 issue and here we are already bringing in 2017. I went back to my messages from the 2016 issues and upon re-reading my January 2016 message, it reminded me of my 2016 New Year's resolutions.<sup>1</sup> I reflected on 2016 events and my resolutions that I set out to achieve. Did I meet them? Did I apply the SMART goal strategy to my resolutions?<sup>1</sup> Should I start the clock again and re-resolve any outstanding resolutions, or perhaps make new ones? I will share that I did meet *most* of my resolutions – but I admit there are still a handful (a metric handful) of resolutions that remain outstanding (How did you make out with your 2016 resolutions?). I ask myself, *self, what prevented me from meeting some of those outstanding resolutions?* So I decided to critically reflect upon these outstanding resolutions to help me strive to meet them now that 2017 is here.

I have taken teaching and learning courses at the University of Guelph and I have been attending many conferences on teaching and learning within the context of university education (ie, teaching adults). Reflection, and specifically critical reflection, is considered an

important activity for self-directed learning and improvement. What is critical reflection? Put simply, it is a reasoning process to make meaning out of an experience. True critical reflection occurs when we analyze and challenge the validity of our presuppositions and assess the appropriateness of our knowledge, understanding, and beliefs, given our present contexts.<sup>2</sup> Critical reflection is not a new concept, and there are many models published that outline or define critical reflection. But the model I appreciate the most is the one by Brookfield<sup>3</sup> that explains critical reflection as a three-stage process:

1. "Identifying the assumptions ('those taken-for-granted ideas, commonsense beliefs, and self-evident rules of thumb') that underlie our thoughts and actions;
2. Assessing and scrutinizing the validity of these assumptions in terms of how they relate to our 'real-life' experiences and our present context(s); and
3. Transforming these assumptions to become more inclusive and integrative, and using this newly-formed knowledge to more appropriately inform our future actions and practices."

As I mentioned, critical reflection is not a new concept and it is an important aspect of veterinary medicine, informing how we continue to improve our knowledge and actions in practice. I just renewed my license to practice veterinary medicine, and a component of the continuing education requirements includes self-critical reflection on the learning exercises-experiences I reported. I used to formally critically reflect on a regular basis (ie, write it down!) but have fallen out of the routine of doing so. Seems now I do most of my reflection at night when I can't sleep and find myself staring

at the ceiling – clearly not a good strategy. Hence, I resolve in 2017 to re-engage in my *active* critical reflection practices, and I encourage you to do so as well! If you have not formally critically reflected on your veterinary practice activities, research methods, conference experiences-learning activities, etc, there are many publications available on how to develop these skills.

---

*"[Critical reflection] is a reasoning process to make meaning out of an experience."*

---

The *Journal of Swine Health and Production* constantly strives to improve. While the journal itself doesn't critically reflect, the authors of the articles share their hard work to help our readers improve upon and perhaps challenge their underlying assumptions about a practice, practices, or research methods. I hope you enjoyed and critically reflected upon the articles from 2016 and the learning opportunity they provided you. I equally hope you enjoy this issue and those that follow for 2017.

All the best to you all for 2017, and I look forward to seeing everyone in Denver this year at the AASV Annual Meeting.

### References

1. O'Sullivan T. New Year's resolutions [editorial]. *J Swine Health Prod.* 2016;24:7.
2. Mezirow J. How critical reflection triggers transformative learning. In: *Fostering Critical Reflection in Adulthood*. Mezirow J, ed. San Francisco: Jossey-Bass Publishers; 1990;1–20.
3. Brookfield SD. Using critical incidents to explore learners' assumptions. In: *Fostering Critical Reflection in Adulthood*. Mezirow J, ed. San Francisco: Jossey-Bass Publishers; 1990;177–193.

Terri O'Sullivan, DVM, PhD  
Executive Editor



# Effects of a nursery feed regimen with spray-dried bovine plasma on performance and mortality of weaned pigs positive for porcine reproductive and respiratory syndrome virus

Joe D. Crenshaw, PhD; Joy M. Campbell, PhD; Javier Polo, PhD; Dan Bussi eres, BSc

## Summary

**Objective:** To compare performance and mortality of weaned pigs positive for porcine reproductive and respiratory syndrome virus (PRRSV) provided either a feed regimen with spray-dried bovine plasma (SDBP) or a feed regimen with a combination of alternative proteins and additives (ALT).

**Materials and methods:** Pigs ( $n = 960$ ) weaned at 21 days of age were allotted by sex and initial body weight (BW) into four nursery rooms, each with 10 pens and 24 pigs per pen. Pigs were provided either the SDBP or ALT regimen, each with three phases

(phase 1, days 1-14; phase 2, days 15-21; phase 3, days 22-48 post weaning). Phase 1 and 2 diets for the SDBP regimen contained 5.0% and 2.5% SDBP, respectively, and phase 1 and 2 diets for the ALT regimen contained combinations of specialty proteins and additives as alternatives to SDBP. All pigs were fed a common phase 3 diet.

**Results:** Pigs fed the SDBP regimen had higher ( $P < .05$ ) average BW at days 14, 21, 28, 35, 42, and 48 post weaning. Cumulative average daily weight gain and average daily feed intake were higher ( $P < .05$ ) for pigs fed the SDBP regimen. There was a tendency

( $P = .07$ ) for pigs fed the SDBP regimen to have lower mortality (21 of 480 pigs) compared to the ALT regimen (35 of 480 pigs).

**Implications:** Under these conditions, PRRSV-positive pigs fed the SDBP regimen have greater final BW and tend to have lower mortality compared to pigs fed the ALT regimen.

**Keywords:** swine, specialty proteins, spray-dried bovine plasma, porcine reproductive and respiratory syndrome virus, mortality

**Received:** January 30, 2016

**Accepted:** June 28, 2016

**Resumen - Efecto de un r egimen alimenticio en destete con plasma bovino secado por aspersi n en el desempe o y mortalidad de cerdos destetados positivos al virus del s ndrome reproductivo y respiratorio porcino**

**Objetivo:** Comparar el desempe o y mortalidad de cerdos destetados positivos al virus del s ndrome reproductivo y respiratorio porcino (PRRSV por sus siglas en ingl s) provistos con un r egimen alimenticio con plasma bovino secado por aspersi n (SDBP por sus siglas en ingl s) o un r egimen alimenticio con una combinaci n de prote nas alternativas y aditivos (ALT por sus siglas en ingl s).

**Materiales y m todos:** Se distribuyeron cerdos ( $n = 960$ ) destetados a los 21 d as de edad, por sexo y peso corporal inicial (BW por sus siglas en ingl s) en cuatro salas de

destete, cada uno con 10 corrales y 24 cerdos por corral. A los cerdos, se les ofreci  con un r egimen ALT o SDBP, cada uno con tres fases (fase 1, d as 1-14; fase 2, d as 15-21; fase 3, d as 22-48 post destete). Las dietas fase 1 y fase 2 del r egimen SDBP tuvieron un contenido de 5.0% y 2.5% SDBP, respectivamente, y las dietas fase 1 y fase 2 del r egimen ALT tuvieron un contenido de combinaciones de aditivos y prote nas especializadas como alternativas para el SDBP. Todos los cerdos fueron alimentados con una dieta com n fase 3.

**Resultados:** Los cerdos alimentados con el r egimen SDBP tuvieron un peso corporal promedio m s alto ( $P < .05$ ) en los d as 14, 21, 28, 35, 42, y 48 post destete. La ganancia de peso diaria promedio acumulada y el consumo de alimento diario promedio fueron m s alto ( $P < .05$ ) en los cerdos alimentados

con el r egimen SDBP. Hubo una tendencia ( $P = .07$ ) en los cerdos alimentados con el r egimen SDBP a tener una mortalidad m s baja (21 de 480 cerdos), comparado con el r egimen ALT (35 de 480 cerdos).

**Implicaciones:** Bajo estas condiciones, los cerdos positivos al PRRSV alimentados con el r egimen SDBP tienen un peso final mayor y tienden a tener una mortalidad m s baja, comparado con los cerdos alimentados con el r egimen ALT.

**R esum  - Effet d'un r egime alimentaire en pouponni re avec du plasma bovin d shydrat  vaporis  sur les performances et la mortalit  de porcelets sevr s positifs pour le virus du syndrome reproducteur et respiratoire porcine**

**Objectif:** Comparer les performances et la mortalit  de porcelets sevr s positifs pour le virus du syndrome reproducteur et respiratoire porcine (VSRPP) nourris avec un r egime alimentaire avec du plasma bovin d shydrat  vaporis  (PBDV) ou un r egime alimentaire avec une combinaison de prote nes alternatives et d'additifs (ALT).

**Mat riels et m thodes:** Des porcs ( $n = 960$ ) sevr s   21 jours d' ge ont  t  r partis par sexe et poids corporel initial (PC) dans quatre

JDC, JMC, JP: Research Department, APC Inc, Ankeny, Iowa.

DB: Demeter Veterinary Services Inc / Groupe C r s Inc, St-Nicolas, Quebec, Canada.

**Corresponding author:** Dr Joe Crenshaw, Research Department, APC Inc, 2425 SE Oak Tree Court, Ankeny, IA 50021; Tel: 1-515-289-7603; Fax: 1-515-289-4362; E-mail: [joe.crenshaw@functionalproteins.com](mailto:joe.crenshaw@functionalproteins.com).

This article is available online at <http://www.aasv.org/shap.html>.

Crenshaw JD, Campbell JM, Polo J, et al. Effects of a nursery feed regimen with spray-dried bovine plasma on performance and mortality of weaned pigs positive for porcine reproductive and respiratory syndrome virus. *J Swine Health Prod.* 2017;25(1):10-18.

chambres de pouponnière, chacune avec 10 enclos et 24 porcs par enclos. Les porcs ont reçu soit le régime PBDV ou ALT, chacun réparti en trois phases (phase 1, 1-14 jours; phase 2, 15-21 jours; phase 3, 22-48 jours post-sevrage). Les diètes des phases 1 et 2 du régime PBDV contenaient 5,0% et 2,5% de PBDV, respectivement, et les phases 1 et 2 du régime ALT contenaient des combinaisons de protéines de spécialité et des additifs en tant qu'alternatives au PBDV. Tous les porcs ont été nourris avec un aliment commun pour la phase 3 de la diète.

**Résultats:** Les porcs nourris avec le régime PBDV avaient un PC moyen plus élevé ( $P < 0,05$ ) aux jours 14, 21, 28, 35, 42, et 48 post-sevrage. Le gain de poids quotidien cumulé et la consommation journalière moyenne étaient supérieurs pour les porcs nourris avec le régime PBDV ( $P < 0,05$ ). Il y avait une tendance ( $P = 0,07$ ) pour les porcs nourris avec le régime PBDV d'avoir une plus faible mortalité (21 des 480 porcs) comparativement au régime ALT (35 des 480 porcs).

**Implications:** Dans les conditions de la présente étude, les porcs positifs pour VSRRP et nourris avec le régime PBDV avaient un PC final plus élevé et avaient tendance à avoir une plus faible mortalité comparativement aux porcs nourris avec le régime ALT.

**P**orcine reproductive and respiratory syndrome (PRRS) has a large impact on annual production losses, with estimates at \$45 million for the Quebec swine industry<sup>1</sup> and about \$664 million estimated annual losses in the United States.<sup>2</sup> Vaccines have been used with variable success to control PRRS.<sup>3</sup> However, PRRS has persisted in several swine-producing countries globally since its emergence more than 25 years ago. Pigs of all ages can be affected by PRRS, and this disease can modulate the immune response to facilitate its own persistence and transmission and increase risk of co-infection.<sup>4</sup>

Pigs weaned from a sow herd during an outbreak of PRRS may be lethargic, with a compromised immune system that can make it more difficult to manage pig health during the weaning process.<sup>5</sup> In addition, multiple stressors associated with weaning contribute to post-weaning growth lag.<sup>6</sup> Spray-dried animal plasma (SDAP) of porcine (SDPP) or bovine (SDBP) origin is used as a protein ingredient in diets for weaned pigs during the critical post-weaning stress period due to the well-known beneficial effects such diets

have on post-weaning growth rate, feed intake, and survival.<sup>7</sup> Pigs experimentally challenged with PRRS virus (PRRSV) and fed a diet with SDPP had a more rapid rate of viral clearance with less interstitial pneumonia, which may have been enhanced by modulation of IL-1 and IFN- $\gamma$  in lung tissue.<sup>8,9</sup>

Spray-dried animal plasma of either bovine or porcine origin is available for commercial use in various countries globally, depending upon governmental regulations associated with country and species origin of SDAP. In addition, some customers may have a preference for bovine or porcine origin products. A recent study<sup>10</sup> reported similar performance of pigs fed either bovine or porcine spray-dried plasma at 6% of the diet for the initial 14 days post weaning, suggesting that species origin of SDAP could be used interchangeably in formulations at the same concentration in the diet. However, published information regarding use of SDBP in nursery diets, and specifically fed to pigs positive for PRRSV, has not been reported. Therefore, the objective for this study was to determine the effects of a nursery-feed regimen with SDBP on performance and mortality of PRRSV-positive pigs, compared to a feed regimen used as an alternative to SDBP (ALT).

## Materials and methods

### Animal care and welfare

This field study was conducted under commercial conditions in a facility that provided recommended stocking density, ventilation, animal care, and welfare according to the code of practice for the care and handling of pigs developed by the National Farm Animal Care Council of Canada in 2014. During the experiment, animal health was monitored by licensed veterinarians, and animals were not manipulated beyond what would be required for diagnostic purposes.

**Animals and housing.** The experiment was conducted at a commercial research nursery facility by staff from Demeter Services Vétérinaires Inc, Lévis, Quebec, and Groupe Cérés Inc, St-Nicholas, Quebec. Four mechanically ventilated nursery rooms, each with 10 pens (1.8  $\times$  3.78 m) housing 24 pigs per pen at a stocking density of 0.28 m<sup>2</sup> per pig, were used for the experiment. All pens had fully slatted plastic flooring with a four-space, single-sided dry feeder, one adjustable-height nipple drinker, and one water-bowl drinker. All pigs were weaned from a sow farm in

Québec that had been confirmed positive for PRRSV within the previous month. All pigs were transported from the sow farm and placed in the nursery on the same day. Pigs (Fast F1 females  $\times$  Fast Duroc sires; Fast Genetics, Saskatoon, Saskatchewan) were weaned at 20 to 21 days of age and allotted to pens according to body weight (BW) and sex. Pigs were visually sorted into three BW groups (small, average, and large) by sex such that each pen of 24 pigs included eight pigs representing each BW group. After the initial visual allocation to pens, individual pigs were weighed and ear-tagged. Additional pig movements were made to assure that there was less than 2.5 kg total pen weight variance within each pen in a block. Blocks consisted of two pens of each sex, with equal assignment of feed regimen within block and within room. Thus, there were five blocks per room for a total of 20 pens (10 pens, castrates; 10 pens, females) per feed regimen. The average initial BW was  $6.0 \pm 0.01$  kg for the 960 pigs used in the experiment.

**Feed regimen.** Two different nursery-feed regimens were provided to pigs used in this experiment (Table 1). Both feed regimens included a phase 1 diet fed from day 1 to 14, a phase 2 diet fed from day 15 to 21, and a common phase 3 diet fed from day 22 to 48, post weaning. One feeding regimen (ALT) had a highly complex phase 1 diet that consisted of a combination of alternative specialty proteins, including dried yeast culture (PFS; Probiotech International, Saint-Hyacinthe, Quebec, Canada), enzymatically hydrolyzed egg and fish protein concentrate (PiggyMax; Premier Ag Resources, Ltd, London, Ontario, Canada), highly digestible poultry protein (Stim-A-tein; XFE Products, Des Moines, Iowa), and other feed additives, including acidifiers, betaine, enzymes, flavors, organic acids, plant extracts, prebiotics, probiotics, sodium butyrate, and sweeteners. The SDBP regimen had a less complex phase 1 diet containing 5% SDBP (AP920; APC Nutrition Ltd, Calgary, Alberta, Canada), and 10 of the dietary feed additives used in the ALT phase 1 diet were excluded from the SDBP phase 1 diet. The feed additives excluded from the SDBP phase 1 diet were betaine, calcium formate, ortho-phosphoric acid, plant extract, prebiotics, probiotics, protease, sodium butyrate, and two sweetener products.

The ALT phase 2 diet contained a combination of PiggyMax, sodium butyrate, and soy protein concentrate, while the SDBP phase 2 diet contained 2.5% AP920. The phase 3 diet was common to both feed regimens.

Both phase 1 diets contained 440 mg per kg chlortetracycline, 125 mg per kg copper, 31.8 mg per kg tiamulin, and 2500 mg per kg zinc oxide. Both phase 2 diets contained 440 mg per kg chlortetracycline, 125 mg per kg copper, and 2000 mg per kg zinc oxide. The phase 3 common diet did not contain antibiotics, but included 125 mg per kg copper and 250 mg per kg zinc oxide. The vitamin-trace mineral premix used in all diets for each phase contained copper and zinc. In addition, phase 1 and 2 diets were provided supplemental zinc oxide as shown in Table 1.

The experimental diets were formulated to contain very similar nutrient content by phase (Table 2) and met or exceeded the National Research Council nutrient guidelines for

swine.<sup>11</sup> The sources of ingredient nutrient values used for formulation of the diets included a combination of internal feed-mill analytical results of major ingredients, such as grain and soybean meal, values from the National Research Council guidelines for swine,<sup>11</sup> net energy values from the National Institute of Agricultural Research,<sup>12</sup> and supplier specifications for specialty products and additives. The diets were manufactured at Meunerie Soucy, St-Edouard, Quebec, Canada. Diet mixing and processing was supervised by Groupe Cérès staff to ensure that each diet formulation was mixed and processed correctly. The phase 1 and 2 diets were pelleted and granulated with a #3 and #4 granulated setting, respectively. The common phase 3 diet was pelleted. The pelleting temperature for all experimental diets

ranged between 68°C and 74°C. All feeds were offered ad libitum. The cost of each diet was calculated using current ingredient price at the start of the trial and using a common margin for manufacturing, transport, and sales.

Samples of each batch of the diets were sent to a certified laboratory (Central Testing Laboratory Ltd, Winnipeg, Manitoba, Canada) for standard proximate analysis to confirm that analyzed nutrient composition was within formulation specifications (Table 3). Variances of analyzed versus calculated values adjusted to a 100% dry matter basis for each diet by phase were within normal analytical variation, and these minor variances were not expected to have any specific impact on performance results. Also, the SDBP used in the

**Table 1:** Composition of diets for three-phase nursery feed regimens with either spray-dried bovine plasma (SDBP) or a combination of alternative specialty proteins fed to weaned pigs positive for PRRSV\*

Ingredient (%)	Phase 1 (days 1-14)		Phase 2 (days 15-21)		Phase 3 (days 22-48)
	ALT	SDBP	ALT	SDBP	Common
Corn	21.06	25.57	36.08	38.11	47.34
Wheat	20.00	20.00	20.00	20.00	15.00
Corn DDGS	0.00	0.00	0.00	0.00	7.50
Soybean meal	14.00	14.00	27.50	26.33	24.49
Whey permeate	18.64	18.64	6.21	6.21	0.00
Soy/corn oil blend	4.01	4.36	2.87	2.91	2.15
SDBP†	0.00	5.00	0.00	2.50	0.00
Poultry protein†	3.52	0.00	0.00	0.00	0.00
Soy protein concentrate	9.67	8.62	1.90	0.00	0.00
Egg-fish protein†	3.50	0.00	1.25	0.00	0.00
Dried yeast culture†	1.02	0.00	0.00	0.00	0.00
L-lysine†	0.69	0.60	0.65	0.63	0.72
L-threonine	0.16	0.13	0.15	0.15	0.15
DL-methionine	0.20	0.21	0.17	0.17	0.14
L-tryptophan	0.05	0.03	0.02	0.02	0.03
Limestone	0.39	0.87	0.84	0.90	1.03
Monocalcium phosphate	0.27	0.48	0.85	0.77	0.70
Salt	0.34	0.22	0.42	0.28	0.45
Choline chloride 60%	0.08	0.08	0.05	0.05	0.05
Vitamin-trace mineral premix†	0.25	0.25	0.25	0.25	0.25
Chlortetracycline	0.20	0.20	0.20	0.20	0.00
Tiamulin	0.18	0.18	0.00	0.00	0.00
Zinc oxide (72%)	0.31	0.31	0.25	0.25	0.00

Table 1 continued on page 13

Table 1 continued

Ingredient (%)	Phase 1 (days 1-14)		Phase 2 (days 15-21)		Phase 3 (days 22-48)
	ALT	SDBP	ALT	SDBP	Common
Acidifier†	0.10	0.10	0.10	0.10	0.00
Phytase†	0.03	0.03	0.03	0.03	0.03
Red iron oxide	0.15	0.00	0.15	0.00	0.00
Yellow iron oxide	0.00	0.15	0.00	0.15	0.00
Protease†	0.05	0.00	0.00	0.00	0.00
Calcium formate	0.30	0.00	0.00	0.00	0.00
Ortho-phosphoric acid	0.20	0.00	0.00	0.00	0.00
Sodium butyrate†	0.12	0.00	0.08	0.00	0.00
Betaine†	0.20	0.00	0.00	0.00	0.00
Brewer's yeast prebiotic†	0.20	0.00	0.00	0.00	0.00
Probiotic†	0.05	0.00	0.00	0.00	0.00
Plant extract†	0.03	0.00	0.00	0.00	0.00
Sweetener†	0.08	0.00	0.00	0.00	0.00
Sucram 3D†	0.01	0.00	0.00	0.00	0.00
Cost per kg (Ca\$)	1.11	1.10	0.56	0.62	0.38

\* Performance and mortality were compared in pigs provided a feed regimen with either spray-dried bovine plasma (SDBP) or a combination of alternative specialty proteins and feed additives (ALT) to replace SDBP: three dietary phases per regimen. Phase 1 and 2 diets for the SDBP regimen contained 5.0% and 2.5% SDBP, respectively; phase 1 and 2 diets for the ALT regimen contained combinations of specialty proteins and additives as alternatives to SDBP. All pigs were fed a common phase 3 diet. Weaned pigs (n = 960; 21 days old; 6.0 kg body weight [BW]) allotted by sex and initial BW into each of four nursery rooms (10 pens, 24 pigs/pen). Pen weights recorded at allotment and study days 7, 14, 21, 28, 35, 42, and 48. Individual pig BW recorded at allotment and study days 21 and 48. Individual pig medications and room water medications recorded. Data analyzed as a randomized complete block design using pen as the experimental unit. Weekly and cumulative performance data analyzed using an analysis of variance (ANOVA) model that included feed regimen, block, and the covariance of initial BW. Pen means for mortality percentage and final BW distribution percentile data analyzed using an ANOVA model that included feed regimen and block. Least squares means of all data reported for feed regimen. Probability of the F-test considered nonsignificant at  $P \geq .05$  and a trend at  $P < .10$ .

† Spray-dried bovine plasma (AP920; APC Nutrition Ltd, Calgary, Alberta, Canada); poultry protein (Stim-A-tein; XFE Ingredients, Des Moines, Iowa); egg-fish protein (PiggyMax; Premeire Ag Resources, London, Ontario, Canada); dried yeast culture (Probiotech International, Saint-Hyacinth, Quebec, Canada); L-lysine (Bio-Lys 70; 54.6% lysine); vitamin trace-mineral premix (Starter Micro BNA3500; Meunerie Soucy, St-Edouard, Quebec, Canada); chlortetracycline; tiamulin; acidifier (Porcinat+; JEFO Nutrition Inc, St-Hyacinth, Quebec, Canada); phytase (Phyzyme XP; Danisco Animal Nutrition, St Louis, Missouri); protease (JEFO Nutrition Inc); sodium butyrate (Proformix 650; ProAg Products, Winnipeg, Manitoba); betaine (Betafin; Danisco Animal Nutrition); brewer's yeast prebiotic (IMW50; Quality Technology International, Inc, Elgin, Illinois); probiotic (BioPlus 2B; Chr Hansen, Hoersholm, Denmark); plant extract (X-Tract; Pancosma, Drummondville, Quebec, Canada); sweetener (Crystal Feed Fruity, Laboratoires Phodé Z.I. Alpipôle – 81150 Terssac, France); Sucram 3D (Pancosma, Drummondville, Quebec, Canada).

PRRSV = porcine reproductive and respiratory syndrome virus; ALT = feed regimen with alternative proteins and additives; SDBP = feed regimen with spray-dried bovine plasma; corn DDGS = dried distillers grain with solubles, with corn as the grain source; Ca\$ = currency in Canadian dollars.

experimental diets was confirmed as 100% bovine origin by DNA analysis (Laboratoire Demeter, Lévis, Quebec, Canada).

**Animal health management:** Under attending veterinarian supervision, all pigs received medications in their drinking water as follows: penicillin V (400 g per 20 L water) days 1 to 5; gentamycin sulfate (200 g per 20 L water) days 6 to 7; apramycin sulfate (210 g per 20 L water; Elanco Animal Health, Greenfield, Indiana) plus Vitoselen (vitamin E and Se supplement, 400 g per 20 L water;

JEFO Nutrition Inc, Saint-Hyacinth, Quebec, Canada) days 8 to 10; and amoxicillin trihydrate (1 kg per 30 L water) days 22 to 27 and days 29 to 35 post entry. Depending upon clinical signs, individual pigs received an injection of 0.5 mL enrofloxacin (Baytril 100; Bayer Corp, Mississauga, Ontario) or 0.5 mL ceftiofur hydrochloride (Excenel RTU; Zoetis Inc, Kirkland, Quebec), and individual pig medications were recorded. All pigs were vaccinated at entry and during week 4 of the experiment with

a 3-mL injection of a combination of vaccines administered in an extra-label manner against *Mycoplasma hyopneumoniae*, porcine circovirus type 2, swine influenza virus, and *Hemophilus parasuis*. Also during week 4 of the experiment, all pigs were provided Enterisol ileitis vaccine (Boehringer Ingelheim Vetmedica, Inc, St Joseph, Missouri) in drinking water (500 doses per 2000 pigs) for 6 hours as an extra-label dose recommendation by Demeter Services Vétérinaires Inc, Lévis, Quebec.

**Table 2:** Calculated nutrient composition of experimental diets by feed regimen phase\*

Nutrients†	Phase 1 (days 1-14)		Phase 2 (days 15-21)		Phase 3 (days 22-48)
	ALT	SDBP	ALT	SDBP	Common
Dry matter (%)	89.75	89.40	88.20	88.06	87.95
Crude protein (%)	22.30	21.65	20.92	20.56	19.71
Fat (%)	6.83	5.68	5.00	4.72	4.82
Net energy (kcal/kg)	2630	2630	2500	2500	2475
Total lysine (%)	1.57	1.58	1.43	1.44	1.32
SID lysine (%)	1.45	1.45	1.31	1.31	1.20
SID methionine (%)	0.51	0.48	0.45	0.44	0.41
SID methionine + cysteine (%)	0.84	0.84	0.76	0.76	0.70
SID threonine (%)	0.90	0.90	0.81	0.81	0.75
SID tryptophan (%)	0.28	0.28	0.24	0.24	0.21
SID valine (%)	0.94	0.96	0.85	0.85	0.79
SID isoleucine (%)	0.86	0.80	0.78	0.74	0.70
SID lysine:net energy‡	5.53	5.53	5.25	5.25	4.85
Calcium (%)	0.70	0.70	0.70	0.70	0.68
Phosphorus (%)	0.60	0.59	0.59	0.58	0.54
Available phosphorus (%)	0.50	0.50	0.45	0.45	0.40
Sodium (%)	0.40	0.40	0.25	0.25	0.20
Added zinc (mg/kg)	2500	2500	2000	2000	250
Added copper (mg/kg)	125	125	125	125	125
Added selenium (mg/kg)	0.30	0.30	0.30	0.30	0.30
Vitamin A (IU/kg)	12,000	12,000	12,000	12,000	12,000
Vitamin D (IU/kg)	1500	1500	1500	1500	1500
Vitamin E (IU/kg)	85	85	85	85	85
Lactose (%)	15.0	15.0	5.0	5.0	0.0
Phytase (FTU/kg)	750	750	750	750	750

\* Study described in Table 1. Diets were formulated to meet the nutrient requirements by phase.<sup>11</sup>

† Nutrient values reported on an as-fed basis.

‡ SID lysine:net energy ratio = SID lysine (g/kg) ÷ net energy (Mcal/kg).

ALT = feed regimen with alternative proteins and additives; SDBP = feed regimen with spray-dried bovine plasma; SID = standardized ileal digestible amino acid; FTU = phytase units per kg of feed.

**Evaluation of PRRSV status.** Within 1 day after allotment, blood samples were collected from 40 pigs (one pig per pen in each room) and submitted to Laboratoire Demeter, Lévis, Quebec, Canada, to assess PRRSV status using an ELISA (Idexx PRRS X3 AB; Idexx Laboratories, Westbrook, Maine) for detection of antibodies. The sample-to-positive (S:P) control ratio for the ELISA was considered negative if 0.000 to 0.199, suspect if 0.200 to 0.399, and positive if  $\geq 0.400$ . Also, real-time quantitative reverse transcription-polymerase chain reaction (qRT-PCR) analysis for the PRRSV genome (EZ-PRRSV

MPX 4.0; Tetracore Veterinary Products, Rockville, Maryland) and PRRSV sequencing were performed on four pooled samples representing 10 pigs per pool according to procedures recommended by the University of Minnesota Veterinary Diagnostic Laboratory for North American and European PRRSV open reading frame 5 sequencing. A cycle to threshold (Ct) value of  $< 37$  for qRT analysis for PRRSV was considered positive.

**Production measures.** Pen weights of pigs were recorded at allotment and days 7, 14, 21, 28, 35, 42, and 48 of the experiment.

Individual pig weights were also recorded at allotment and days 21 and 48 of the experiment. During the course of the experiment, the weight, date, and tag number of each dead or removed pig were also recorded. Average daily weight gain (ADG) was calculated by the weekly and cumulative weigh periods from pen weights adjusted for pig days that included weights of dead or removed pigs during a particular week. The appropriate feed treatment assigned to each pen was distributed using a feed cart equipped with a scale that allowed for accurate measurement

**Table 3:** Analyzed composition of experimental diets by feed regimen phase\*

	Phase 1 (days 1-14)		Phase 2 (days 15-21)		Phase 3 (days 22-48)
	ALT	SDBP	ALT	SDBP	Common
<b>Samples analyzed</b>	<b>4</b>	<b>4</b>	<b>2</b>	<b>2</b>	<b>8</b>
<b>Crude protein (%)</b>					
Calculated†	24.85	24.22	23.72	23.35	22.41
Analyzed‡	24.45 ± 0.81	23.40 ± 0.35	22.84 ± 0.58	22.93 ± 0.97	22.06 ± 0.76
<b>Crude fat (%)</b>					
Calculated	7.61	6.35	5.67	5.36	5.48
Analyzed	7.32 ± 0.51	6.37 ± 0.39	6.06 ± 0.43	5.15 ± 0.02	5.50 ± 0.17
<b>Calcium (%)</b>					
Calculated	0.78	0.78	0.79	0.79	0.77
Analyzed	0.83 ± 0.04	0.79 ± 0.01	0.76 ± 0.06	0.79 ± 0.01	0.77 ± 0.03
<b>Phosphorus (%)</b>					
Calculated	0.67	0.66	0.67	0.66	0.61
Analyzed	0.75 ± 0.01	0.73 ± 0.01	0.71 ± 0.00	0.74 ± 0.01	0.67 ± 0.02
<b>Sodium (%)</b>					
Calculated	0.45	0.45	0.28	0.28	0.23
Analyzed	0.42 ± 0.02	0.44 ± 0.02	0.26 ± 0.01	0.27 ± 0.01	0.25 ± 0.03

\* Study described in Table 1.

† Calculated nutrient value for diet by phase adjusted to 100% dry matter basis.

‡ Mean ± standard deviation of samples analyzed for each batch of diet used in the experiment with values adjusted to 100% dry matter basis. ALT = feed regimen with alternative proteins and additives; SDBP = feed regimen with spray-dried bovine plasma.

of the feed added to a feeder. The feed-cart scale was calibrated on a regular basis with a standardized weight. Each time pigs were weighed, feeders were individually vacuumed and the quantity of unused feed was weighed. The phase 1 and 2 ALT diets had added red color, while the phase 1 and 2 SDBP diets had added yellow color (Table 1) to assure that animal caretakers could distinguish a visual color difference between the experimental diets. Average daily feed intake (ADFI) was calculated per pen by the weekly and cumulative weigh periods. Feed efficiency (gain-to-feed; GF) per pen was calculated as ADG per ADFI by weekly and cumulative weigh periods.

**Statistical analysis.** The data were analyzed as a randomized complete block design using pen (40 pens, 24 pigs per pen) as the experimental unit. Weekly and cumulative performance data were analyzed using an analysis of variance (ANOVA) model that included feed regimen, block, and the covariance of initial BW. Pen means for mortality percentage and final BW distribution percentile data were analyzed using an ANOVA model that included feed regimen

and block. Least squares means of all data are reported for feed regimen, and the probability of the F-test was considered nonsignificant at  $P \geq .05$  and a trend at  $P < .10$ .

## Results

Serological testing indicated 31 of 40 pigs sampled at entry were seropositive ( $S:P \geq 0.4$ ) for antibodies against PRRSV. Results of qrt-PCR for the PRRSV genome of four pooled serum samples (10 samples per pool) were strongly positive (Ct value < 29.9, range 22.2 to 28.7). The PRRSV strain was 99.34% homologous with the strain at the sow farm.

Of the pigs fed the SDBP and ALT regimens, 459 of 480 and 445 of 480, respectively, survived to the end of the experiment (Table 4). Mortality over the entire study (days 1 to 48) tended ( $P = .07$ ) to be lower for pigs fed the SDBP regimen than for those fed the ALT regimen.

PRRS virus-positive pigs fed the SDBP regimen had greater ( $P < .05$ ) average BW by 14 days post weaning than did pigs fed the ALT regimen, and this greater average BW

for pigs fed the SDBP regimen was maintained through the end of the study at day 48 (Table 4). A higher ( $P < .05$ ) percentage of pigs fed the ALT regimen were in the lower 25<sup>th</sup> percentile of final BW (< 23.6 kg BW) at day 48, compared to the percentage of pigs fed the SDBP regimen. Cumulative ADG and ADFI were higher ( $P < .05$ ) during days 1 to 14, days 1 to 21, and days 1 to 48 of the experiment for pigs fed the SDBP regimen than for those fed the ALT regimen. Feed efficiency (GF) was higher ( $P < .05$ ) for pigs fed the SDBP regimen than for pigs fed the ALT regimen during days 1 to 21, when the feed contained SDBP; however, cumulative feed efficiency (days 1 to 48) did not differ between feed regimens by the end of the study.

On the basis of Canadian currency (Ca\$) and an assumed value for a feeder pig of \$2.20 per kg BW, there was a \$1.06 advantage in margin over feed and medication costs for pigs fed the SDBP regimen (Table 5). Medication cost was slightly higher for pigs fed the SDBP regimen due to more individual injectable medications given to the SDBP group (264)

**Table 4:** Cumulative performance and mortality by feed regimen and phase of experiment\*

	Feed regimen		SEM†	P‡
	ALT	SDBP		
<b>Phase 1 (days 1-14)</b>				
Initial BW (kg)	6.00	5.98	0.01	.19
BW day 14 (kg)	9.81	10.06	0.05	< .01
ADG (g)	265	280	4.2	.03
ADFI (g)	255	272	3.7	< .01
GF	1.04	1.03	0.01	.44
Mortality (%)§	3.33	2.50	0.59	.33
<b>Phase 1-2 (days 1-21)</b>				
BW day 21 (kg)	12.34	12.95	0.09	< .01
ADG (g)	295	321	4.7	< .01
ADFI (g)	355	378	4.4	< .01
GF	0.83	0.85	0.01	< .01
Mortality (%)§	5.00	3.75	0.86	.32
<b>Phase 1-3 (days 1-48)</b>				
Final BW day 48 (kg)	27.67	28.58	0.19	< .01
Lower 25 <sup>th</sup> BW (< 23.6 kg) (%)§	19.48	13.51	1.36	< .01
Mid 50 <sup>th</sup> BW (23.6-33.6 kg) (%)§	67.39	70.51	1.92	.26
Upper 25 <sup>th</sup> BW (> 33.6) (%)§	13.13	15.97	1.65	.24
ADG (g)	435	454	3.9	< .01
ADFI (g)	631	655	5.9	< .01
GF	0.69	0.69	0.00	.32
Mortality (%)§	7.29	4.39	1.07	.07

\* Study described in Table 1. Values are least squares means for 20 pens (24 pigs/pen) per feed regimen by phase of experiment, analyzed as a randomized complete block design with feed regimen, block, and covariance of initial BW in the model.

† Standard error of the least squares mean.

‡ Probability of F-test for feed regimen, considered nonsignificant at  $P \geq .05$  and a trend at  $P < .10$ .

§ Values are least squares means of 20 pens per feed regimen by phase of experiment for percentage mortality or percentage of pigs by lower, mid, or upper final BW percentiles analyzed as a randomized complete block design with feed regimen and block in the model.

ALT = feed regimen with alternative proteins and additives; SDBP = feed regimen with spray-dried bovine plasma; BW = average body weight; ADG = average daily weight gain; ADFI = average daily feed intake; GF = gain-to-feed ratio.

versus the ALT group (215). The phase 1 SDBP diet was less complex and expensive than the phase 1 ALT diet; however, the phase 2 SDBP diet was more expensive than the phase 2 ALT diet (Table 1). Pigs fed the SDBP regimen consumed more feed, and feed cost was \$0.62 more per pig completing the study.

## Discussion

The economic impact of PRRS can result in large reductions in revenue due to mortality and morbidity.<sup>1,2</sup> Severity of PRRS on productivity may vary considerably depending upon viral strain and the adaptive immune status of the afflicted pigs.

In the current study, serum samples subjected to ELISA and qrt-PCR confirmed that sampled pigs were considered PRRSV-positive at placement, and this was consistent with the stated objective for the study.

Water medications for all rooms and individual pig medications were given primarily during the initial 3 weeks of the study to treat diarrhea and respiratory signs commonly associated with PRRSV-positive pigs. In addition, all experimental diets fed during the initial 21 days of the study contained antibiotics and supplemental zinc and copper in anticipation of higher morbidity and mortality associated with PRRSV-positive pigs. The potential impact of antibiotics in

the water and feed on intestinal microflora and performance results of the PRRSV-positive pigs fed the different feed regimens is unknown. Antibiotic therapy may have influenced the ability of some ingredients, such as acidifiers, prebiotics, or probiotics used in the ALT regimen, to enhance gut microflora for the benefit of animal health and performance. However, it may also have influenced the pig performance response to the SDBP regimen as well. Past research has reported increased lactobacilli in ileal and cecal digesta of pigs fed diets with spray-dried animal plasma (SDAP).<sup>13</sup> In addition, a review of studies comparing ADG of pigs provided diets with or



**Table 5:** Margin over feed and medication cost per pig completing experiment\*

	Feed regimen		Variance
	SDBP	ALT	
Pigs started experiment	480	480	0.00
Pigs completed experiment	459	445	14
Average BW day 48 (kg)†	28.96	28.19	0.77
Feeder pig value (Ca\$)‡	63.71	62.02	1.69
Feed/pig (kg)§	32.53	31.86	0.67
Feed cost/pig (Ca\$)¶	16.35	15.73	0.62
Medication cost/pig (Ca\$)**	1.61	1.60	0.01
MOFMC (Ca\$)††	45.75	44.69	1.06

\* Study described in Table 1.

† Sum of individual BW of pigs at day 48 divided by number of pigs completing experiment.

‡ Assumed \$2.20 (Ca\$) per kg BW value if sold as a feeder pig.

§ Sum of total feed per regimen divided by pigs completing experiment.

¶ Sum of cost of feed (Ca\$) per phase divided by pigs completing experiment.

\*\* Sum of cost (Ca\$) of individual pig medications and water medications divided by number of pigs completing experiment.

†† MOFMC (margin over feed and medication cost) = feeder pig value (Ca\$) minus feed and medication costs (Ca\$) per pig completing experiment.

SDBP = feed regimen with spray-dried bovine plasma; ALT = feed regimen with alternative proteins and additives; BW = body weight; Ca\$ = currency in Canadian dollars.

without SDAP and with or without antimicrobials reported higher ADG for pigs provided feed containing SDAP compared to feed containing no SDAP, regardless of presence or absence of antimicrobials in the feed.<sup>7</sup> However, in this review, only some of the studies reported a significant interaction of SDAP and antimicrobials in feed.

PRRS virus-positive pigs fed less complex diets with SDBP had higher final BW, ADG, ADFI, and a tendency for improved survival compared to pigs on the ALT feed regimen, even though diets within phase were formulated to have equal energy and lysine content. These results are consistent with an extensive review<sup>7</sup> of 143 experiments comparing performance of pigs provided diets with SDAP to performance of pigs provided diets with other specialty proteins, including blood protein, casein, dried skim milk, fish meal, meat extract, pea protein isolate, potato protein, soybean meal, soy protein concentrate, wheat gluten, or whey protein, which showed that pigs fed diets with SDAP had higher ADG and ADFI, compared to pigs fed diets with all of the other protein sources during the initial 2 weeks after weaning. In the current study, 5% SDBP in the phase 1 diet was replaced by a combination of dried yeast culture, enzymatically hydrolyzed egg and fish protein (PiggyMax; Premier Ag Resources), highly

digestible protein from the proprietary transformation of poultry (Stim-A-tein; XFE Ingredients), and 10 other feed additives that included betaine, calcium formate, ortho-phosphoric acid, plant extracts, prebiotics, probiotics, proteases, sodium butyrate, and sweeteners. In the phase 2 diets, 2.5% SDBP was replaced by a combination of PiggyMax, sodium butyrate, and soy protein concentrate. Although these specialty proteins and additives in general may improve digestibility of diets and potentially support a more favorable gastrointestinal microflora, they were not as cost effective as using the SDBP regimen, under the conditions of this study. Furthermore, the administrative costs for procurement, labeling, inventory, and maintenance of all of these specialty proteins and additives to replace SDBP were not disclosed and could not be considered in the economic analyses.

Concentration of SDAP in the diet and feeding duration of the diet are important factors for minimizing inflammation-associated gut-barrier dysfunction during the critical 2 weeks after weaning.<sup>14</sup> For these reasons, it is recommended to use 4% to 6% SDAP in starter diets fed for at least the initial 2 weeks after weaning to support pig performance during weaning stress and minimize adverse effects of stress-related events

later in life. In addition, other research has demonstrated better survival and performance of nursery pigs afflicted with porcine circovirus type 2-associated disease when spray-dried porcine plasma was included in a three-phase feeding regimen at 6%, 3%, and 1.5% of the respective diets by phase, compared to a three-phase feed regimen using fish meal to replace spray-dried porcine plasma.<sup>15</sup> The extended duration of feeding diets with SDBP planned for the PRRSV-positive pigs in the current study was based on the results of past research.

Multiple functional components contained in plasma have been associated with the well-known beneficial effects on performance of pigs fed starter diets containing SDAP.<sup>7</sup> Some authors have suggested the globulin portion of plasma, which contains antibodies, is responsible for most of the beneficial effects associated with animals fed diets with SDAP.<sup>16,17</sup> Antibodies against various pathogens are found in plasma, and their neutralizing capacity is maintained after spray drying.<sup>18</sup> Past studies<sup>8,9</sup> have shown that pigs fed diets with SDPP and experimentally challenged with PRRSV had a greater rate of viral clearance post infection, with less interstitial pneumonia, which was associated with modulation of TH1 cytokines in lung tissue, compared to

PRRSV-challenged pigs fed a diet without SDPP. Rodent species used in inflammatory models and fed diets containing SDAP had beneficial modulation of cytokines in enteric, respiratory, and reproductive mucosal tissues.<sup>19-22</sup> Collectively, these studies suggest that multiple functional components in plasma elicit the beneficial effects associated with animals fed diets containing SDAP.

Spray-dried bovine plasma has been shown to be just as effective as SDPP for improving growth of pigs when used at the same concentration in the diet.<sup>7,10</sup> In the current study, the higher performance values and survival of PRRSV-positive pigs fed the SDBP regimen were maintained to the end of the study, even when pigs were no longer fed SDBP. The BW advantage for the SDBP regimen resulted in a \$1.06 advantage in margin over medication and feed cost, assuming pigs were sold as feeder pigs.

## Implications

- Under the conditions of this study, the use of spray-dried bovine plasma in a nursery-feed regimen for PRRSV-positive pigs is more cost effective than an alternative regimen.
- Under the conditions of this study, pigs PRRSV-positive at weaning and fed nursery diets with alternative specialty proteins and other feed additives may not perform or tend to survive as well as pigs fed nursery diets with SDBP.

## Conflict of interest

Drs Joe Crenshaw, Joy Campbell, and Javier Polo are employed by APC Inc, that manufactures and sells SDAP.

Dan Bussi eres has no conflict of interest.

## Acknowledgement

The authors sincerely appreciate M elanie Larochelle, MSc, from Demeter Services V et erinaires Inc, L evis, Quebec, Canada, for her hard work involved with the collection of data and summary of results.

## Disclaimer

Scientific manuscripts published in the *Journal of Swine Health and Production* are peer reviewed. However, information on medications, feed, and management techniques may be specific to the research or commercial situation presented in the manuscript. It is the responsibility of the reader to use information responsibly and

in accordance with the rules and regulations governing research or the practice of veterinary medicine in their country or region.

## References

- \*1. Surprenant, C. Vivre avec le SRRP, peut-on encore se le transmettre? [Living with PRRS, Can we still afford it?]. *Le Rendez-vous porcine AQUINAC*. Drummondville, Qu ebec. 2010;25–33.
2. Holtkamp DJ, Kliebenstein JB, Neumann EJ, Zimmerman JJ, Rotto HF, Yoder TK, Wang C, Yeske PE, Mowrer CL, Haley CA. Assessment of the economic impact of porcine reproductive and respiratory syndrome virus on United States pork producers. *J Swine Health Prod*. 2013;21:72–84.
3. Charentantanakul W. Porcine reproductive and respiratory syndrome virus vaccines: Immunogenicity, efficacy and safety aspects. *World J Virol*. 2012;1:23–30.
4. Mateu E, D iaz I. The challenge of PRRS immunology. *Vet J*. 2008;177:345–351.
5. Murtaugh MP, Xiao Z, Zuckermann F. Immunological responses of swine to porcine reproductive and respiratory syndrome virus infection. *Viral Immunology*. 2002;15:533–547.
6. Campbell JM, Crenshaw JD, Polo J. The biological stress of early weaned piglets. *J Anim Sci Biotech*. 2013;4:19–22.
7. Torralardona D. Spray dried animal plasma as an alternative to antibiotics in weanling pigs – A review. *Asian-Aust J Anim Sci*. 2010;23:131–148.
8. Pujols J, Lorca-Or o C, D iaz I, Russell LE, Campbell JM, Crenshaw JD, Polo J, Mateu E, Segal es J. Commercial spray-dried porcine plasma does not transmit porcine circovirus type 2 in weaned pigs challenged with porcine reproductive and respiratory syndrome virus. *Vet J*. 2011;190:e16–e20.
- \*9. Diaz I, Lorea C, Gallindo I, Campbell J, Barranco I, Kuzemseva L, Rodriguez-Gomez IM, Crenshaw J, Russell L, Polo J, Pujols J. Potential positive effect of commercial spray-dried porcine plasma on pigs challenged with PRRS virus. *Proc IPVS*. Vancouver, Canada. 2010;560.
- \*10. Crenshaw JD, Campbell JM, Polo J. Comparison of spray dried bovine plasma and spray dried porcine plasma in diets for weaned pigs [poster]. *J Anim Sci*. 2015;93(Suppl2):138–139.
11. Southern LL, Adeola O, De Lange CF, Hill GM, Kerr BJ, Lindemann MD, Odle J, Stein HH, Trotter NL. Chapter 17: Feed ingredient composition. In: *Nutrient Requirements of Swine*. 11<sup>th</sup> ed. National Research Council. Washington, DC: The National Academies Press; 2012:242–367.
12. Sauvant D, Perez JM, Tran G. In: *Tables of composition and nutritional value of feed materials: pigs, poultry, sheep, goats, rabbits, horses, fish*. National Institute of Agricultural Research. Paris, France, ed. Wageningen, The Netherlands: Wageningen Academic Press. 2004.
13. Torralardona D, Conde MR, Badiola I, Polo J, Brufau J. Effect of fishmeal replacement with spray-dried animal plasma and colistin on intestinal structure, intestinal microbiology, and performance of weanling pigs challenged with *Escherichia coli* K99. *J Anim Sci*. 2003;81:1220–1226.
14. Peace RM, Campbell J, Polo J, Crenshaw J, Russell L, Moeser A. Spray-dried porcine plasma influences intestinal barrier function, inflammation and diarrhea in weaned pigs. *J Nutr*. 2011;141:1312–1317.

\*15. Mor es N, Ciacci-Zanella JR, Amara AL, Cordebella A, Lima GJMM, Miele M, Zanella E, Ranget LFS, Lima ES, Zancanaro M. Spray dried porcine plasma in nursery and grower feed reduces the severity of Porcine Circovirus associated diseases. *Proc Allen D Leman Swine Conf Recent Research Reports*. 2007;34:3.

16. Owusu-Asiedu A, Baidoo SK, Nyachoti CM, Marquardt RR. Response of early-weaned pigs to spray dried porcine or animal plasma-based diets supplemented with egg-yolk antibodies against enterotoxigenic *Escherichia coli*. *J Anim Sci*. 2002;80:2895–2903.
17. Pierce JL, Cromwell GL, Lindemann MD, Russell LE, Weaver EM. Effects of spray-dried animal plasma and immunoglobulins on performance of early weaned pigs. *J Anim Sci*. 2005;83:2876–2885.
18. Polo J, Opriessnig T, O’Neill KC, Rodriguez C, Russell LE, Campbell JM, Crenshaw J, Segal es J, Pujols J. Neutralizing antibodies against porcine circovirus type 2 in liquid pooled plasma contribute to the biosafety of commercially manufactured spray-dried porcine plasma. *J Anim Sci*. 2013;91:2192–2198.
19. Moret o M, P erez-Bosque A. Dietary plasma proteins, the intestinal immune system, and the barrier functions of the intestinal mucosa. *J Anim Sci*. 2009;87(E Suppl):E92–E100.
20. Maij o M, Mir o L, Polo J, Campbell J, Russell L, Crenshaw J, Weaver E, Moret o M, P erez-Bosque A. Dietary plasma proteins attenuate the innate immunity response in a mouse model of acute lung injury. *Brit J Nutr*. 2011;107:867–875.
21. Maij o M, Mir o L, Polo J, Campbell J, Russell L, Crenshaw J, Weaver E, Moret o M, P erez-Bosque A. Dietary plasma proteins modulate the adaptive immune response in mice with acute lung inflammation. *J Nutr*. 2012;142:264–270.
22. Song M, Liu Y, Lee JJ, Che TM, Soares-Almeida JA, Chun JL, Campbell JM, Polo J, Crenshaw JD, Seo SW, Pettigrew JE. Spray-dried plasma attenuates inflammation and improves pregnancy rate of mated female mice. *J Anim Sci*. 2015;93:298–305.

\*Non-refereed references.



# Factors that influence mechanical transmission of porcine reproductive and respiratory syndrome virus at the time of unloading animals into slaughter plant lairage

James Lowe, DVM, MS; Ryan McCann, DVM; Laura Greiner, PhD

## Summary

**Objectives:** To estimate the impact of environmental conditions and management practices on the likelihood of cross-contamination of a pig transport vehicle with porcine reproductive and respiratory syndrome virus (PRRSV) during market-animal unloading.

**Materials and methods:** An experimental model was developed to simulate indirect contact involving footwear between an unloading dock and a pig transport vehicle. Two experiments were conducted. Experiment 1 evaluated temperature on the model trailer (4°C, 15°C, or 28°C) for 60 minutes after contact with the contaminated dock (32 contact replicates per temperature). In

Experiment 2, conditions on the model dock were evaluated in a 2 × 2 × 2 factorial arrangement with repeated measures. Main effects were temperature (4°C or 32°C), ultraviolet light (ambient or supplemental), and mechanical scraping (de-bulked or not) with four contact events per combination. Samples were collected using a “Swiffer” (Procter & Gamble, Cincinnati, Ohio). All samples were tested for PRRSV using reverse-transcription polymerase chain reaction.

**Results:** Experiment 1: Temperature did not affect the amount of PRRSV RNA recovered. If PRRSV RNA was detected on the model dock, it was transferred and detected on the model trailer 80% of the time (95% CI,

70.0%-90.0%). Experiment 2: De-bulking resulted in a significant reduction in the likelihood of transfer (odds ratio = 0.14; 95% CI, 0.06-0.32).

**Implications:** Contact at the harvest plant lairage unloading is a risk factor for PRRSV transmission with inadequate livestock trailer hygiene. This risk can be mitigated through mechanical removal of gross contamination of the dock.

**Keywords:** swine, porcine reproductive and respiratory syndrome virus, transportation, biosecurity

**Received:** December 29, 2015

**Accepted:** June 21, 2016

## Resumen - Factores que influyen la transmisión mecánica del virus del síndrome reproductivo y respiratorio porcino al momento de descargar los animales a los corrales de la planta de sacrificio

**Objetivos:** Evaluar el impacto de las condiciones medio ambientales y prácticas de manejo en la probabilidad de contaminación cruzada de un vehículo de transporte porcino con el virus del síndrome reproductivo y respiratorio porcino (PRRSV por sus siglas en inglés) durante la descarga de animales de rastro.

**Materiales y métodos:** Se desarrolló un modelo experimental para simular contacto indirecto involucrando calzado entre un área de descarga y un vehículo de transporte porcino. Se realizaron dos experimentos. El experimento 1 evaluó la temperatura en el tráiler modelo (4°C, 15°C, ó 28°C) por 60 minutos después del contacto con el área contaminada (32 réplicas de contacto por cada temperatura). En el experimento 2, se evaluaron las condiciones en el área modelo de descarga en un arreglo factorial de 2 × 2 × 2 con medidas repetidas. Los efectos principales fueron temperatura (4°C ó 32°C), luz

UV (ambiental o suplementaria), y raspado mecánico (a conciencia o no) con cuatro eventos de contacto por cada combinación. Las muestras se recolectaron utilizando un “Swiffer” (Procter & Gamble, Cincinnati, Ohio). Todas las muestras se analizaron en busca del PRRSV utilizando la reacción en cadena de polimerasa de transcriptasa reversa.

**Resultados:** Experimento 1: La temperatura no afectó la cantidad de ARN de PRRSV recuperada. Si se detectó RNA de PRRSV en el área de descarga modelo, ésta se transfirió y se detectó en el tráiler modelo en 80% de las veces (95% CI, 70.0%-90.0%). Experimento 2: La disminución a conciencia del material, resultó en una reducción significativa en la probabilidad de transferencia (índice de probabilidad = 0.14; 95% CI, 0.06-0.32).

**Implicaciones:** El contacto en la planta de sacrificio con los corrales de descarga es un factor de riesgo para la transmisión del PRRSV si no hay una higiene adecuada del camión de transporte. Este riesgo puede ser mitigado por medio de la remoción de la contaminación del área de descarga.

JL, RMC: Integrated Food Animal Medicine Systems, Department of Veterinary Clinical Medicine, University of Illinois, Urbana, Illinois.

LG: Carthage Innovative Swine Solutions, PO Box 220, Carthage, Illinois.

**Corresponding author:** Dr James F. Lowe, 239 LAC, Integrated Food Animal Medicine Systems, Department of Veterinary Clinical Medicine, University of Illinois, 1008 W Hazelwood Dr, Urbana, IL 61802; Tel: 217-300-6398; Fax: 217-244-1475; E-mail: [jlowe@illinois.edu](mailto:jlowe@illinois.edu).

This article is available online at <http://www.aasv.org/shap.html>.

Lowe J, McCann R, Greiner L. Factors that influence mechanical transmission of porcine reproductive and respiratory syndrome virus at the time of unloading animals into slaughter plant lairage. *J Swine Health Prod.* 2017;25(1):19-23.

## Résumé - Facteurs influençant la transmission mécanique du virus du syndrome reproducteur et respiratoire porcin au moment du transbordement des animaux vers l'aire de stabulation d'un abattoir

**Objectifs:** Estimer l'impact des conditions environnementales et des pratiques de gestion sur la probabilité de contamination croisée d'un véhicule de transport porcin avec le virus du syndrome reproducteur et respiratoire porcin (VSRRP) durant le déchargement d'animaux à l'abattoir.

**Matériels et méthodes:** Un modèle expérimental a été développé pour imiter les contacts indirects impliquant les chaussures entre un quai de déchargement et un véhicule de transport de porcs. Deux expériences ont été menées. L'Expérience 1 a évalué la température sur le modèle de remorque (4°C, 15°C, ou 28°C) pendant 60 minutes après un contact avec un quai contaminé (32 réplifications de contact par température). Dans l'Expérience 2, les conditions sur le modèle de quai ont été évaluées dans un arrangement factoriel de type 2 × 2 × 2 avec des mesures répétées. Les principaux effets ont été la température (4°C ou 32°C), les rayons UV (ambiant ou en ajout), et le grattage mécanique (avec réduction ou non) avec quatre événement de contact par combinaison. Les échantillons ont été prélevés à l'aide d'un "Swiffer" (Procter & Gamble, Cincinnati, Ohio). Tous les échantillons ont été testés pour le VSRRP en utilisant une réaction d'amplification en chaîne par la polymérase avec la transcriptase reverse.

**Résultats:** Expérience 1: La température n'a pas affecté la quantité d'ARN du VSRRP récoltée. Si l'ARN du VSRRP était détecté sur le modèle de quai, il était transféré et détecté sur le modèle de remorque 80% du temps (95% IC, 70,0%-90,0%). Expérience 2: La réduction par grattage a entraîné une réduction significative de la probabilité de transfert (rapport de cote = 0,14; IC, 0,06-0,32).

**Implication:** Les contacts dans la zone de stabulation d'un abattoir est un facteur de risque pour la transmission du VSRRP par des remorques à bétail dont l'hygiène est inadéquate. Ce risque peut être atténué en enlevant de manière mécanique la contamination évidente du quai.

Porcine reproductive and respiratory syndrome (PRRS) is a widespread viral disease in the pork industry that can cause poor growth in developing pigs, and infertility and abortion issues in adult pigs.<sup>1</sup> The estimated annual cost of lost production in the United States was over

\$664 million dollars.<sup>2</sup> In grow-finish, the estimated cost in 2013 was approximately \$361.8 million due to poor feed efficiency, poor average daily gain, and high mortality.<sup>2</sup> The cost of PRRS in 2005 was significantly higher than for other swine diseases prior to eradication, such as hog cholera and pseudorabies.<sup>3</sup>

PRRS virus (PRRSV) can survive outside the host for extended periods of time<sup>4,5</sup> and spreads between herds at a high rate annually.<sup>6</sup> Multiple potential routes of movement of PRRSV between herds have been identified, including pig introductions,<sup>6,7</sup> aerosols,<sup>8-12</sup> livestock trucks,<sup>13,14</sup> insects,<sup>15</sup> fomites,<sup>16</sup> and fecal material.<sup>17</sup> This was further elucidated in a series of experiments that demonstrated that PRRSV could move between herds through a coordinated series of events in both warm<sup>18</sup> and cold<sup>14</sup> weather.

While transport vehicles were identified early on as a potential route of PRRSV transmission,<sup>13</sup> and considerable work has been done on trailer disinfection and decontamination,<sup>19,20</sup> little work has been done to evaluate how trailers can become contaminated with PRRSV. One of the high-risk contact points for livestock trailers is the unloading dock of harvest plant lairage and other market collection points. It is common to transport pigs to harvest plants on equipment that has not been cleaned and disinfected between loads. Implementation of all-in, all-out growing-pig sites, where all pigs from the previous group are removed prior to arrival of the next group, limits the impact of disease introduced by transport vehicles. In many cases, the risks and associated cost of disease introduced late in the growing period are thought to be less than the cost of cleaning and disinfecting live-haul transportation equipment. In the United States, transport vehicles are often shared between different pig owners, allowing for the spread of disease across large regions.

Lowe et al<sup>21</sup> demonstrated that trailers free of porcine epidemic diarrhea virus (PEDV) could be contaminated with PEDV at the time of unloading at harvest plant lairage and that more contact at the plant resulted in a higher likelihood of contamination with PEDV. We hypothesized that PRRSV, like PEDV, could be transferred from a loading dock at the harvest plant to livestock trailers and serve as a route of PRRSV transmission between sites and production regions, depending on where the trailer next loaded pigs. This article describes a series of experiments that estimate the likelihood of PRRSV cross-contamination occurring from

a contaminated unloading dock at a slaughter facility to a pig transport vehicle under various environmental conditions, and evaluates the effectiveness of management practices in minimizing this risk.

## Material and methods

### Contact model

A model of the live-haul trailer and unloading dock was developed to simulate the foot contact that occurs under commercial conditions. This model allowed for manipulation of physical conditions and replication that is not possible under commercial conditions. Our model employed a 68-L plastic tub (Sterilite 18 Gallon Tote Box; Sterilite Corp, Townsend, Massachusetts) to mimic the unloading area of the lairage dock. The model dock was contaminated with a mixture of 1 L of feces from PRRSV-negative and PEDV-negative pigs and 1 L of new pine shavings to simulate material found on livestock trailers. The 1L of feces was mixed with 10 mL of modified-live PRRS vaccine (Ingelvac PRRS MLV; Boehringer Ingelheim Vetmedica Inc, St Joseph, Missouri) prior to mixing with the shavings to serve as a source of contamination.

The foot contact event was modeled by using a clean plastic boot cover (MaxiBoot; Neogen Corp, Lexington, Kentucky) to step from the model dock onto a model trailer. A model trailer was simulated using a new aluminum cooking tray (40.6 cm × 29.2 cm 7000-45 disposable aluminum cookie sheet; Durable Packaging Inc, Wheeling, Illinois). The plastic boot was changed between replicates, and people with similar shoe sizes were used for all contacts. For each contact event, samples were collected using a "Swiffer" (Procter & Gamble, Cincinnati, Ohio) in a manner that has been previously described.<sup>21</sup> Briefly, sample collection consisted of rubbing a Swiffer moistened with phosphate-buffered saline over an approximately 100-cm<sup>2</sup> area. The Swiffer was placed in a sterile bag (Whirl-Pac; NASCO, Fort Atkinson, Wisconsin) and the liquid was collected after applying manual pressure. The liquid was transferred to a sterile tube (14-mL Falcon Tube; Fisher Scientific, Chicago, Illinois) and immediately placed on ice. Samples were collected from the boot before contact and from the model trailer before contact to validate that cross-contamination was not present prior to the contact event. All aluminum sheets (model trailers) were placed in new individual plastic bags after the contact event and prior to their sampling at 60 minutes post contact to minimize the likelihood

that cross-contamination of the surface would occur. Latex gloves were changed between samplings to minimize the likelihood of cross-contamination.

## Physical conditions

### Experiment 1, model trailer conditions.

An experimental design of 32 contact replicates of each of three post-contact temperatures on the model trailer (4°C, 15°C, or 28°C) was utilized. Samples were collected from the model dock prior to contact, from the model trailer immediately after contact, and again from the model trailer 60 minutes post contact at each of the three temperatures.

**Experiment 2, model dock conditions.** A 2 × 2 × 2 factorial arrangement with repeated measures was used to assess the effects of temperature (4°C or 32°C), ultraviolet (UV) light (ambient or supplemental), and mechanical scraping (de-bulked or not) on the risk and amount of PRRSV RNA transferred from the model dock to the model trailer. We simulated four contact events (replications) for each condition. In both the cold (4°C) and hot (32°C) conditions, the model dock was cooled or warmed and temperatures were monitored using an infrared thermometer at the sampling area. The 4°C temperature condition was achieved by placing the model dock in an ice and water bath; the temperature was adjusted by adding more ice to the water. The 32°C condition was created by placing a 250w heat lamp over the model dock; the temperature was adjusted by moving the heat source closer or farther away from the sampling surface.

Increased UV light was achieved by using a 60w UV light bulb 60 cm above the floor of the tub. Prior to de-bulking, the contaminated material was stirred in the tub for 2 minutes by hand to achieve contact with all of the surfaces at the bottom of the tub and to simulate repeated stepping of pigs and people on fecal material on a real dock. Following the manual stirring of the material, the tub was turned upside down and tapped on the ground one time to simulate the act of scraping the dock with a metal scraper at a commercial lairage dock. This left visible contamination on the floor of the model dock. Four contact events for each condition were conducted at 0, 5, 10, and 60 minutes following application of the condition (temperature, UV, or de-bulking) to the dock. Model trailers were sampled 60 minutes after the contact event.

## Laboratory analysis

All samples were held at -20°C from collection until they were shipped to the laboratory on dry ice for analysis. Samples were submitted to the Iowa State University Veterinary Diagnostic Laboratory and analyzed as a single batch for each experiment using their commercially available reverse-transcription polymerase chain reaction (rtPCR) for PRRSV RNA. Briefly, RNA extraction was performed with 100 µL of each environmental sample by using the MagMAX Pathogen RNA/DNA Kit (ThermoFisher Scientific, Carlsbad, California) and a Kingfisher 96 instrument (Thermo Scientific, Waltham, Massachusetts) and Kingfisher program AM\_1836\_DW\_HV\_v3 provided by the manufacturer of the extraction kits. Viral RNA was eluted into 90 µL of buffer. Real-time reverse-transcription PCR (qRT-PCR) was performed on nucleic acid extracts using the VetMAX NA and EU PRRSV Reagents (ThermoFisher Scientific) according to the manufacturer's recommendations. All qRT-PCR reactions were conducted on an ABI 7500 Fast (Applied Biosystems, Foster City, California) and results analyzed by system software. Samples were tested separately from routine diagnostic samples in the laboratory to minimize risks for cross-contamination.

## Statistical analysis

All data were analyzed using Statistix 10.0 (Analytical Software Inc, Tallahassee, Florida). The cycle threshold (Ct) values were transformed to base 2 logarithms to stabilize the variance prior to analysis. Model-adjusted, back-transformed means are reported. For all analyses, a *P* value of < .05 was considered significant.

**Experiment 1.** A general analysis of variance (ANOVA) model with the main effect of temperature was utilized to assess the impact of temperature (4°C, 15°C, or 28°C) on the mean log<sub>2</sub> Ct values at 60 minutes post contact. The model was co-varied for the log<sub>2</sub> Ct on both the model dock at the time of contact and on the model trailer immediately after contact. A multivariate logistic regression model to predict the probability of detecting PRRSV RNA on the model trailer was constructed using positive PCR status at 60 minutes as the dependent variable and temperature on the trailer, Ct value at time 0 on the model dock, and Ct value at time 0 on the model trailer as independent variables. Replicate was included as a case

variable. To assess the possibility of a correlation between the amount of PRRSV RNA detected on the model dock and the amount of PRRSV RNA transferred to the model trailer immediately after contact, a simple linear regression model was constructed with the log<sub>2</sub> Ct value on the dock as the independent variable and the log<sub>2</sub> Ct value on the model trailer as the dependent variable.

**Experiment 2:** A multivariate logistic regression model to predict the probability of detecting PRRSV RNA on the model trailer 60 minutes post contact event was constructed, with positive PCR status at 60 minutes as the dependent variable and each of the three treatment variables and sampling time included as predictor variables. Replicate was included as a case variable. A repeated measures ANOVA model was constructed. The dependent variable was log<sub>2</sub> Ct at 60 minutes post contact with between-subject factors of temperature, UV light, and de-bulking. The subject factor was contact replicate and the within-subject factor was sampling time (0 and 60 minutes). All one-, two-, and three-way potential interactions were included in the model.

## Results

**Experiment 1.** Temperature at which the model trailer was held did not affect the amount of PRRSV RNA recovered (ie, mean Ct value) 60 minutes after contact (*P* = .36). If PRRSV RNA was detected on the model dock prior to contact, PRRSV RNA was transferred and detected on the model trailer 80% of the time (95% CI, 70.0%-90.0%). The amount of PRRSV RNA detected on the model dock was positively correlated with the amount of PRRSV RNA detected on the model trailer immediately after contact (correlation coefficient [*R*<sup>2</sup>] = 0.56; *P* < .001).

**Experiment 2.** Debulking reduced the risk of PRRSV RNA transfer from the model dock to the model trailer (OR = 0.14; 95% CI, 0.06-0.32) (*P* < .001). Interestingly, high temperature on the dock (32°C) increased the risk of PRRSV RNA transfer from the model dock to the model trailer (OR = 2.7; 95% CI, 1.43-5.10) (*P* = .001). This is not consistent with the a priori prediction of higher temperatures resulting in less transmission and is likely an artifact of many values (87.5%) within 1 Ct of the positive-negative cut point and the high sample size needed to detect interactions in the factorial model. Ultraviolet light had no effect on the risk of PRRSV transmission

in this model. The amount of PRRSV RNA detected at 60 minutes post contact event was not influenced by temperature or UV light, but was lower by a small but statistically significant amount (0.37 Ct;  $P = .034$ ) that is likely biologically unimportant. Results are summarized in Table 1. Time from dock contamination to the contact event (0 or 60 minutes) was not associated with changes in the amount or probability of PRRSV RNA transfer from the model dock to the model trailer.

## Discussion

The goal of this study was not to prove that we could eliminate transmission of PRRSV at packing plants, but what might be practical ways to reduce that transmission in a manner that could be implemented at scale, in all types of weather, across the multitude of lairage dock designs in US packing plants. None of the methods evaluated were intended to replace trailer washing and sanitation, but were to serve as a supplement to good trailer sanitation practices and system-level biosecurity measures. To the authors' knowledge, there have been no systematic assessments published of the behaviors of people at the lairage unloading dock or potential risk reduction intervention strategies. These experiments served as an initial attempt to understand what methods, using a small-scale model that could be replicated, might have benefit to investigate at scale and line speed in a processing plant.

The results of Experiment 1 suggest that trailers contaminated at the harvest plant unloading dock are likely to still be contaminated when they return to the production system, regardless of the temperature outside. In periods of higher contamination at the harvest plant, which can be assumed to be periods of higher industry prevalence, the trailer is likely to be contaminated with PRRSV RNA, thus increasing the risk of the trailer to transmit virus to another site. These data are supported by findings for porcine epidemic diarrhea virus (PEDV) that demonstrated that when larger amounts of PEDV were identified at the packing plant, more PEDV was likely to be identified on trailers leaving the plant.<sup>21</sup> Taken in total, without intentional hygiene procedures for livestock trailers, contamination with PRRSV at the harvest plant unloading dock results in contaminated outbound livestock trailers returning to production systems approximately 80% of the time. Thus, trailers returning to production systems after delivering pigs to a packing plant

**Table 1:** Effect of model lairage dock conditions on mean porcine reproductive and respiratory syndrome virus (PRRSV) reverse-transcription polymerase chain reaction cycle threshold (Ct) values and probability of PRRSV transfer to a model livestock transportation trailer\*

Condition		Treatment applied	
		No	Yes
Heated	Mean Ct	35.84	35.97
	P value for mean Ct	0.24	
	OR (95% CI) for transfer	2.7 (1.43-5.10)	
Increased UV	Mean Ct	35.86	35.95
	P value for mean Ct	.45	
	OR (95% CI) for transfer	NS	
Debulked	Mean Ct	35.63	36.00
	P value for mean Ct	.03	
	OR (95% CI) for transfer	0.14 (0.06-0.32)	
	SEM	1.02	

\* Odds ratio is expressed for the effect that applying the condition has on the change in risk of transfer of PRRSV RNA from model dock to the model trailer. Values < 1 indicate that the condition (heat, high UV, debulking) reduced the risk of virus transfer from dock to trailer, and values > 1 indicate that the condition increased the risk of transfer. A repeated measures factorial design was used to evaluate the impact of heat (32°C versus 4°C), UV light (supplemental or natural light), and removal of gross contamination (debulked or not debulked) at two time points, 0 and 60 minutes after a contact event. A multivariate logistic regression model was used to predict the probability of detecting PRRSV RNA on the model trailer 60 minutes post contact event. A repeated measures ANOVA model was constructed to compare means that included all one-, two-, and three-way potential interactions. Model-adjusted, back-transformed mean Ct values are reported. OR = odds ratio; UV = ultraviolet; NS = not statistically significant,  $P \geq .05$ ; SEM = standard error of the mean.

serve as an effective fomite for the spread of PRRS between production sites.

Removal of gross contamination of the dock by mechanical means is likely to be an effective tool to limit the contamination risk of trailers with PRRSV RNA, regardless of temperature outside or periods of low UV light. This could be a meaningful intervention to apply in commercial practice, as it could be accomplished in all weather conditions, would likely not require significant capital investment at the harvest plant, and appears, under these experimental conditions, to reduce by seven-fold the risk of a trailer being contaminated with PRRSV RNA at the harvest plant. While an approach of scraping will reduce the risk of contamination, it will not eliminate it, as the immediate dock area is not the only contact point between the plant and the trailer. The office and ground are contacted by 100% of truckers observed at a series of seven packing plants in 2013 as part of an evaluation of the risk of PEDV transmission at harvest lairage,<sup>21</sup> (JL, unpublished

data). In the same study,<sup>21</sup> where plant personnel entered the trailer to observe or assist with pig unloading or conduct euthanasia on non-ambulatory pigs, the risk of PEDV contamination of the trailer was greater than that for trailers they did not enter (OR 4.15; 95% CI, 1.27-13.54).

A weakness of these data is that no testing was conducted for infectivity of the samples where PRRSV RNA was detected. There is no way to know if the samples that were rt-PCR-positive were infectious or if there was only non-infectious RNA present, as virus isolation or pig bioassays were not attempted. In previous studies investigating the risks of PRRS transmission, all PCR-positive, virus isolation-negative samples were infectious to pigs,<sup>14</sup> suggesting that a high percentage of these PCR samples would still be infectious. The issue of infectivity of samples collected from any study is a significant challenge. While virus isolation or pig bioassay samples that were positive would have added to the argument that any intervention was

not effective, negative infectivity tests are not as revealing, as the sensitivity of those diagnostic assays limits the ability to understand and apply negative results.

These experiments confront the age-old scientific issue of proving a negative, and that what is true under model conditions is likely to not hold up under the high number of contacts in the real world. With thousands of trucks being unloaded in the United States each day, even a small reduction in sensitivity of the model could have disastrous results if any of these methods was assumed to block the route of transmission. Therefore, we chose to use an approach more sensitive (likely to find all of the true positives) but less specific to our model development (less likely to prove that a given approach does not result in infectious virus, as PCR-positive samples may not be infectious). These choices were made in light of the goals of screening approaches that would be more likely to be successful at scale and under real-world conditions of packing plants in the United States. Further research is needed in packing plants to validate if debulking alone will be adequate to reduce the contamination rate of trailers at the packing plant lairage dock.

## Implications

- Taken in total, these data suggest that contact at the harvest plant lairage is a risk factor for PRRSV RNA transmission between sites when inadequate hygiene is practiced on livestock trailers.
- Mechanical removal of gross contamination of the dock may serve as a way to reduce the probability of livestock trailer contamination with PRRSV at the time of unloading.
- Further work is needed to validate these data under field conditions and to model the impact of a risk reduction of this magnitude on PRRSV transmission risks at the industry level.

## Conflict of interest

None reported.

## Disclaimer

Scientific manuscripts published in the *Journal of Swine Health and Production* are peer reviewed. However, information on medications, feed, and management techniques may be specific to the research or commercial situation presented in the manuscript. It is the responsibility of the reader to use information responsibly and

in accordance with the rules and regulations governing research or the practice of veterinary medicine in their country or region.

## References

1. Christianson WT, Collins JE, Benfield DA, Harris L, Gorcyca DE, Chladek DW, Morrison RB, Joo HS. Experimental reproduction of swine infertility and respiratory syndrome in pregnant sows. *Am J Vet Res.* 1992;53:485–488. Available at <http://europepmc.org/abstract/med/1586017>. Accessed 5 October 2016.
2. Holtkamp DJ, Kliebenstein SB, Newmann EJ, Zimmermann JJ, Roto H. Assessment of the economic impact of porcine reproductive and respiratory syndrome virus on United States pork producers. *J Swine Health Prod.* 2013;21:72–84.
3. Neumann EJ, Kliebenstein JB, Johnson CD, Mabry JW, Bush EJ, Seitzinger AH, Green AL, Zimmerman JJ. Assessment of the economic impact of porcine reproductive and respiratory syndrome on swine production in the United States. *J Am Vet Med Assoc.* 2005;227:385–392. doi:10.2460/javma.2005.227.385.
4. Pirtle EC, Beran GW. Stability of porcine reproductive and respiratory syndrome virus in the presence of fomites commonly found on farms. *J Am Vet Med Assoc.* 1996;208:390–392. Available at <http://europepmc.org/abstract/med/8575971>. Accessed 5 October 2016.
5. Benfield DA, Nelson E, Collins JE, Harris L, Goyal SM, Robison D, Christianson WT, Morrison RB, Gorcyca D, Chladek D. Characterization of swine infertility and respiratory syndrome (SIRS) virus (isolate ATCC VR-2332). *J Vet Diagn Invest.* 1992;4:127–133.
- \*6. Swine Health Monitoring Project. Swine Health Information Center. National PRRS Incidence/Prevalence: July 2016-June 2017. Available at [cihedging.com/assets/cih/hogmargin/SHMP.pdf](http://cihedging.com/assets/cih/hogmargin/SHMP.pdf). Accessed 02 November 2016.
7. Bierk MD, Dee SA, Rossow KD, Otake S, Collins JE, Molitor TW. Transmission of porcine reproductive and respiratory syndrome virus from persistently infected sows to contact controls. *Can J Vet Res [Rev Can Rech vétérinaire].* 2001;65:261–266. Available at <http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=1189689&tool=pmcentrez&rendertype=abstract>. Accessed 5 October 2016.
8. Cho JG, Deen J, Dee SA. Influence of isolate pathogenicity on the aerosol transmission of Porcine reproductive and respiratory syndrome virus. *Can J Vet Res.* 2007;71:23–27. Available at <http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=1635995&tool=pmcentrez&rendertype=abstract>. Accessed 5 October 2016.
9. Pitkin A, Deen J, Dee S. Use of a production region model to assess the airborne spread of porcine reproductive and respiratory syndrome virus. *Vet Microbiol.* 2009;136:1–7. doi:10.1016/j.vetmic.2008.10.013.
10. Brito B, Dee S, Wayne S, Alvarez J, Perez A. Genetic diversity of PRRS virus collected from air samples in four different regions of concentrated swine production during a high incidence season. *Viruses.* 2014;6:4424–4436. doi:10.3390/v6114424.
11. Kristensen CS, Bøtner A, Takai H, Nielsen JP, Jorsal SE. Experimental airborne transmission of PRRS virus. *Vet Microbiol.* 2004;99:197–202. doi:10.1016/j.vetmic.2004.01.005.
12. Dee S, Otake S, Deen J. Use of a production region model to assess the efficacy of various air filtration systems for preventing airborne transmission of porcine reproductive and respiratory syndrome virus and *Mycoplasma hyopneumoniae*: Results from a 2-year study. *Virus Res.* 2010;154:177–184.
13. Dee SA, Deen J, Otake S, Pijoan C. An experimental model to evaluate the role of transport vehicles as a source of transmission of porcine reproductive and respiratory syndrome virus to susceptible pigs. *Can J Vet Res.* 2004;68:128–133. Available at <http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=1142156&tool=pmcentrez&rendertype=abstract>. Accessed 5 October 2016.
14. Dee S, Deen J, Rossow K, Wiese C, Otake S, Joo HS, Pijoan C. Mechanical transmission of porcine reproductive and respiratory syndrome virus throughout a coordinated sequence of events during cold weather. *Can J Vet Res.* 2002;66:232–239. Available at <http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=227010&tool=pmcentrez&rendertype=abstract>. Accessed 5 October 2016.
15. Otake S, Dee SA, Rossow KD, Moon RD, Pijoan C. Mechanical transmission of porcine reproductive and respiratory syndrome virus by mosquitoes, *Aedes vexans* (Meigen). *Can J Vet Res.* 2002;66:191–195. Available at <http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=227003&tool=pmcentrez&rendertype=abstract>. Accessed 24 November 2016.
16. Otake S, Dee SA, Rossow KD, Deen J, Joo HS, Molitor TW, Pijoan C. Transmission of porcine reproductive and respiratory syndrome virus by fomites (boots and coveralls). *J Swine Health Prod.* 2012;10:59–66. Available at <https://aasv.org/shap/issues/v10n2/v10n2p59.pdf>. Accessed 5 October 2016.
17. Linhares DCL, Torremorell M, Joo HS, Morrison RB. Infectivity of PRRS virus in pig manure at different temperatures. *Vet Microbiol.* 2012;160:23–28. doi:10.1016/j.vetmic.2012.05.009.
18. Dee S, Deen J, Rossow K, Weise C, Eliason R, Otake S, Joo HS, Pijoan C. Mechanical transmission of porcine reproductive and respiratory syndrome virus throughout a coordinated sequence of events during warm weather. *Can J Vet Res.* 2003;67:12–19. Available at <http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=227022&tool=pmcentrez&rendertype=abstract>. Accessed 24 November 2016.
19. Dee SA, Torremorell M, Thompson R, Cano P, Deen J, Pijoan C. Evaluation of the thermo-assisted drying and decontamination system for sanitation of a full-size transport vehicle contaminated with porcine reproductive and respiratory syndrome virus. *J Swine Health Prod.* 2007;15:12–18.
20. Dee SA, Deen J, Pijoan C. Evaluation of an industry-based sanitation protocol for full-size transport vehicles contaminated with porcine reproductive and respiratory syndrome virus. *J Swine Health Prod.* 2006;14:307–311.
21. Lowe J, Gauger P, Harmon K, Zhang J, Connor J, Yeske P, Loula T, Levis I, Dufrense L, Main R. Role of transportation in spread of porcine epidemic diarrhea virus infection, United States. *Emerg Infect Dis.* 2014;20:872–874. doi:10.3201/cid2005.131628.

\* Non-refereed reference.



# Comparison of growth performance under field conditions in growing pigs each vaccinated with one of two commercial modified-live porcine reproductive and respiratory syndrome vaccines

Ikjae Kang, DVM, PhD; Hei Suk Kang, MS; Jiwoon Jeong, DVM; Changhoon Park, DVM, PhD; Kyuhyung Choi, DVM; Su-Jin Park, DVM, MS, PhD; Hwang Ji Sung; Eun Kyung Park; Beomseok Oh; Sung-Hoon Kim, PhD; Chanhee Chae, DVM, MS, PhD

## Summary

Under field conditions, in groups of pigs each vaccinated with one of two modified live virus porcine reproductive and respiratory syndrome vaccines, growth performance was better and lung lesions were fewer than in nonvaccinated controls. Growth performance and number of lung lesions did not differ between the two vaccinated groups.

**Keywords:** swine, porcine reproductive and respiratory syndrome, respiratory disease, vaccine

**Received:** February 11, 2016

**Accepted:** June 28, 2016

**Resumen - Comparación del desempeño de crecimiento bajo condiciones de campo en cerdos en crecimiento vacunados con una de las dos vacunas comerciales vivas modificadas contra el síndrome reproductivo y respiratorio porcino**

Bajo condiciones de campo, en grupos de cerdos vacunados con una de las dos vacunas vivas modificadas del virus del síndrome reproductivo y respiratorio porcino, el desempeño de crecimiento fue mejor y las lesiones de pulmón menores que en los controles no vacunados. El desempeño del crecimiento y el número de lesiones de pulmón no difirieron entre los dos grupos vacunados.

**Résumé - Comparaison des performances de croissance en conditions de champs de porcs en période de croissance vaccinés avec un des deux vaccins vivants modifiés commerciaux contre le syndrome reproducteur et respiratoire porcine**

Dans des groupes de porcs gardés en conditions de champs et chacun vaccinés avec un des deux vaccins vivants modifiés contre le virus du syndrome reproducteur et respiratoire porcine, les performances de croissance étaient meilleures et il y avait moins de lésions pulmonaires que chez les témoins non-vaccinés. Les performances de croissance et la quantité de lésions pulmonaires ne différaient pas entre les deux groupes d'animaux vaccinés.

Porcine reproductive and respiratory syndrome (PRRS) virus is an enveloped positive-stranded RNA virus belonging to the order *Nidovirales*, family *Arteriviridae*, and genus *Arterivirus*.<sup>1</sup> PRRS virus (PRRSV) is divided into type 1 (European) and type 2 (North American) genotypes on the basis of the 3'-terminal structural genes or the entire genome.<sup>2,3</sup> PRRS is one of the most devastating diseases of swine, causing enormous economic losses for the global pork industry due to reproductive failure in sows and respiratory disease in growing pigs.<sup>4</sup> Vaccination is still a

major tool for control of PRRSV infection. Currently, two commercial PRRS modified-live vaccines (MLVs) are available in Korea: Fostera PRRS (Zoetis, Florham, New Jersey) and Ingelvac PRRS MLV (Boehringer Ingelheim Vetmedica Inc, St Joseph, Missouri). Hence, the objective of this study was to compare the efficacy of the two MLV PRRS vaccines, under field conditions, in healthy pigs from a herd infected with type 2 PRRSV.

## Materials and methods

All animal protocols were approved by the

Seoul National University Institutional Animal Care and Use Committee.

The clinical field trial was conducted on a 1000-sow herd with two-site production: farrowing-nursery and growing-finishing system. The farm had suffered recent losses due to respiratory disease caused by type 2 PRRSV in post-weaning and late-growing pigs at the time of the study. However, reproductive failure had been reported in breeding females from the farm 4 months prior to the study. All pigs were routinely vaccinated with a commercial porcine circovirus type 2 (PCV2) vaccine at 3 weeks of age, but clinical signs indicative of PCV2 had not been observed.

Type 2 PRRSV (SNUVR 150324 strain, lineage 5, GenBank no. KU301048) was isolated from lung samples from weaned pigs at 42 days of age, prior to the beginning of this study. The SNUVR 150324 strain and Fostera PRRS vaccine virus (GenBank no. AF494042) share 91.5% nucleotide identity for open reading frame 5 (ORF5). The SNUVR 150324 strain and Ingelvac MLV vaccine virus (GenBank no. AF066183) share 99.1%

IK, HSK, JJ, CP, KC, SJP, CC: Seoul National University, Seoul, Republic of Korea.

HJS: Department of Oriental Pharmacy, College of Pharmacy, Wonkwang University, Republic of Korea.

EKP, BO, SHK: Kyunghee University, Seoul, Republic of Korea.

**Corresponding author:** Dr C. Chae, Seoul National University, College of Veterinary Medicine, 1 Gwanak-ro, Gwanak-gu, 151-742, Seoul, Republic of Korea; Tel: +8228801277; E-mail: [swine@snu.ac.kr](mailto:swine@snu.ac.kr).

This article is available online at <http://www.aasv.org/shap.html>.

Kang I, Kang HS, Jeong J, et al. Comparison of growth performance under field conditions in growing pigs each vaccinated with one of two commercial modified-live porcine reproductive and respiratory syndrome vaccines. *J Swine Health Prod.* 2017;25(1):24–28.



nucleotide identity for ORF5. Foster PRRS vaccine and Ingelvac PRRS MLV vaccine virus share 91.3% nucleotide identity for ORF5.

This study used a randomized, blinded, weight-matched, controlled clinical trial design (Table 1). Sample size was calculated assuming a 90% power ( $1 - \beta = .90$ ) of detecting a difference at the 5% level of significance ( $\alpha = .05$ ), which was based on expected results of average daily gain (ADG).<sup>5</sup> To minimize sow variation, six piglets at 7 days of age were selected from each sow using the random number generator function in Excel (Microsoft Corporation, Redmond, Washington). Pigs were assigned evenly to three groups (30 pigs per group) using the Excel random number generator. Pigs in Group 1 were injected intramuscularly with 2.0 mL of the Foster PRRS vaccine (Zoetis, lot no. A405013B) in the right side of the neck at 21 days of age according to the manufacturer's instructions. Pigs in Group 2 were injected intramuscularly with 2.0 mL of the Ingelvac PRRS MLV (Boehringer Ingelheim Vetmedica Inc, lot no. 245-659A) in the right side of the neck at 21 days of age according to the manufacturer's instructions. Pigs in Group 3 were injected in the same anatomic location with 2.0 mL of phosphate buffered saline (0.01M, pH 7.4).

Pigs in each group were randomly assigned into three pens (10 pigs per pen) using the Excel random number generator and were housed in the same barn. Pigs were monitored daily for physical condition, and mean respiratory scores were recorded once weekly. Scores ranged from 0 (normal) to 6 (severe dyspnea, abdominal breathing, and death) at study days 0 to 91 (Figure 1).<sup>6</sup> Observers were blinded to vaccination status. Mortality rate was calculated as the number of pigs that died divided by the number of pigs initially assigned to that group within batch.

The live weight of each pig in groups 1, 2, and 3 was measured at study days 0 (21 days of age), 49, 91, and 147 (168 days of age). The ADG (grams per pig per day) was analyzed over three time periods: between study days 0 and 49; 49 and 91; 91 and 147, respectively (Table 1). The ADG during these various production stages was calculated as the difference between the starting and final weights divided by the duration of the stage. Data from dead pigs were included in the calculation.

Blood samples from pigs were collected at study days 0, 21, 49, 70, 91, and 147. Blood samples were also collected from sows at study days 0, 21, 49, 70, and 91.

Serum samples from sows at study days 0, 21, 49, 70, and 91 were tested using a commercial PRRSV ELISA (Idexx Laboratories Inc, Westbrook, Maine). Serum samples were considered positive for anti-PRRSV antibody if the sample-to-positive ratio (S:P) was  $\geq 0.4$ , according to the manufacturer's instructions.

QIAamp RNA Mini Kit (Qiagen Inc, Valencia, California) was used to extract RNA from the pigs' serum samples at study days 0, 21, 49, 70, 91, and 147. The RNA extracts were used to quantify the number of PRRSV genomic RNA copies by real-time PCR as previously described.<sup>7,8</sup> Real-time PCR for the vaccine virus was also performed to quantify the number of PRRSV genomic RNA copies.<sup>8,9</sup> Numbers of copies of PRRSV genomic RNA per mL of serum were converted to base 10 logarithms for analysis.

Five serum samples from pigs PCR-positive for field or vaccine virus, randomly selected using the Excel random number generator at study days 21, 49, 70, 91, and 147, were used to analyze the sequence of ORF5 by PCR as previously described.<sup>10</sup> The PCR products were purified using a commercial kit (Wizard PCR Preps DNA Purification and PCR Clean-Up System, Promega, Madison, Wisconsin), cloned with the TOPcloner Blunt kit (Enzynomics, Daejeon, Korea), and propagated in DH5 $\alpha$  competent cells (Enzynomics) according to the manufacturer's instructions. Plasmid DNA was purified with a plasmid purification kit (iNtRON Biotechnology, Sungnam, Kyeonggido, Korea) and sequenced by a commercial service (Sol Gent Co Ltd, Daejeon, Korea). Three clones of each PCR product were independently sequenced at least three times.

Lung samples were collected from all pigs in each group at study day 147 (the time of slaughter). For morphometric analysis of histopathological lesion scores in lungs, eight pieces of lung tissue (two pieces from the right cranial lobe, two from the right middle lobe, one from the ventromedial part of the right caudal lobe, one from the dorsomedial part of the right caudal lobe, one from the mid-lateral part of the right caudal lobe, and one from the accessory lobe) were collected from each pig. Three tissue sections from the eight lung pieces were prepared and examined blindly by two veterinary pathologists (authors JJ and CC) at Seoul National University (Seoul, Republic of Korea) as previously described.<sup>6</sup> Lung lesions were scored on a scale from 0 to 4: 0 = no microscopic lesions; 1 = mild interstitial pneumonia; 2 = moderate multifocal interstitial pneumonia; 3 = moderate diffuse interstitial

pneumonia; and 4 = severe interstitial pneumonia.<sup>6</sup> In situ hybridization for detection and differentiation of type 1 and type 2 PRRSV nucleic acids in lung tissues was performed and analyzed morphometrically as previously described.<sup>9,11</sup>

Statistical analyses were performed using SPSS software (version 21; IBM, Armonk, New York). Continuous data included ADG determined by the difference between the starting and final weights divided by the duration of the stage; PRRSV RNA (numbers of log<sub>10</sub> PRRSV genomic copies per mL) determined by real-time PCR; PRRSV antibody titer; and numbers of lung sections positive for PRRSV nucleic acid per unit area (0.25 mm<sup>2</sup>) determined by in situ hybridization. Continuous data were analyzed using Tukey's multiple comparisons test for comparison between groups in order to estimate the difference at each time point. Discrete data (clinical signs and lung lesion scores) were analyzed with the Kruskal-Wallis test. When the Kruskal-Wallis test was significant, the Mann-Whitney test was performed to determine the significant differences between groups. Fisher's exact test was applied to evaluate mortality rate. A value of  $P < .05$  was considered significant.

## Results

The mean respiratory scores were significantly lower ( $P < .05$ ) in vaccinated pigs (Group 1 and Group 2) than in nonvaccinated pigs (Group 3) from day 49 to 63 (Figure 1). The overall mortality rates were 6.6% (two of 30 pigs) both in Group 1 and in Group 2, and 13.3% (four of 30 pigs) in Group 3. Diagnostic test results indicated the cause of death was primarily streptococcal meningitis in Group 1, primarily pneumonic pasteurellosis in Group 2, and primarily related to Glasser's disease (*Hemophilus parasuis*) in Group 3.

The ADGs were significantly higher ( $P < .05$ ) in vaccinated pigs (Group 1 and Group 2) than in nonvaccinated pigs (Group 3) between day 91 and 147, and between day 0 and 147 (Table 1).

On day 21, anti-PRRSV antibody titers were significantly higher ( $P < .05$ ) in vaccinated pigs (Group 1 and Group 2) than in nonvaccinated pigs (Group 3) (Figure 2). Anti-PRRSV antibody titers were detected in 15 sows, with S:P ratios ranging from 0.4 to 0.7.

Numbers of genomic copies of type 2 PRRS field virus in serum did not differ between vaccinated pigs (Group 1 and Group 2) and nonvaccinated pigs (Group 3)

**Table 1:** Means (with standard deviation) of average daily gain (ADG) in pigs vaccinated for PRRS (Group 1 and Group 2) or injected with phosphate buffered saline (Group 3) at 21 days of age\*

Period between study days	Age (days)	ADG (g/day)		
		Group 1	Group 2	Group 3
0 to 49	21 to 70	400.51 (56.81)	405.77 (41.02)	396.57 (36.86)
49 to 91	70 to 112	631.57 (86.12)	639.13 (80.26)	607.14 (78.75)
91 to 147	112 to 168	786.80 <sup>a</sup> (59.16)	783.07 <sup>a</sup> (71.85)	738.61 <sup>b</sup> (41.41)
0 to 147	21 to 168	615.82 <sup>a</sup> (34.43)	615.85 <sup>a</sup> (29.15)	586.59 <sup>b</sup> (30.38)

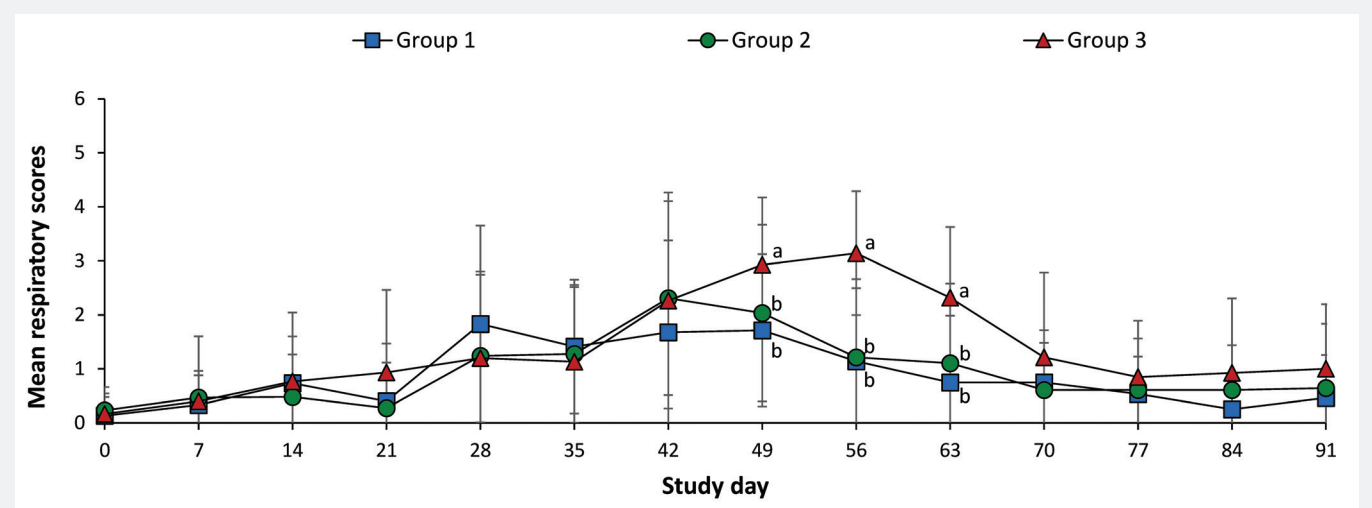
\* To minimize sow variation, six piglets at 7 days of age were selected from each sow using the random number generator function in Excel (Microsoft Corporation, Redmond, Washington) and assigned evenly to three groups (30 pigs per group) using the random number generator. At study day 0 (21 days of age), Group 1 pigs were vaccinated with a one-dose PRRS vaccine (Fostera PRRS; Zoetis, Florham Park, New Jersey); Group 2 pigs were vaccinated with a one-dose PRRS vaccine (Ingelvac PRRS MLV; Boehringer Ingelheim Vetmedica Inc, St Joseph, Missouri); and Group 3 pigs were injected with phosphate buffered saline. The live weight of each pig in each group was measured at study days 0 (21 days of age), 49, 91, and 147 (168 days of age); ADG was compared among the three groups using a Tukey's multiple comparisons test.

<sup>ab</sup> Within a row, values with different superscript letters are significantly different ( $P < .05$ ). PRRS = porcine reproductive and respiratory syndrome.

throughout the experiment. ORF5 sequences from five randomly selected serum samples in all three groups were highly homologous (99.1% to 100%) with field PRRS virus (SNUVR150324 strain). Vaccine virus was detected in the blood of Group 1 (vaccinated pigs) at study days 21 (four pigs) and 49 (one pig). ORF5 sequences from the serum samples of Group 1 (vaccinated pigs) at study days 21 and 49 identified the Fostera PRRS vaccine virus. Vaccine virus was detected in the blood of Group 2 (vaccinated pigs) at study days 21 (five pigs) and 49 (two pigs). ORF5 sequences from the serum samples of Group 2 (vaccinated pigs) at study days 21 and 49 identified the Ingelvac PRRS vaccine virus. Determined by PRRSV ORF5 sequencing after vaccination, cross-contamination of vaccine virus was not observed between Group 1 and Group 2 vaccinated pigs. Vaccine virus was not detected in the blood of nonvaccinated pigs (Group 3). Type 1 PRRSV was not detected in any of the three groups throughout the experiment.

Pulmonary lesion scores were significantly lower ( $P < .05$ ) in vaccinated pigs (Group 1 and Group 2) than in nonvaccinated pigs (Group 3) (Table 2). The number of lung cells positive for type 2 PRRSV nucleic acid was not significantly different between vaccinated pigs (Group 1 and Group 2) (Figure 3) and nonvaccinated pigs (Group 3) (Table 2).

**Figure 1:** Mean respiratory scores (with standard deviation) of pigs in the study described in Table 1. Mean respiratory signs were scored on a scale from 0 to 6: 0 = normal; 1 = mild dyspnea or tachypnea or both when stressed; 2 = mild dyspnea or tachypnea or both when at rest; 3 = moderate dyspnea or tachypnea or both when stressed; 4 = moderate dyspnea or tachypnea or both when at rest; 5 = severe dyspnea or tachypnea or both when stressed; and 6 = severe dyspnea or tachypnea or both when at rest at study days 0, 7, 14, 21, 28, 35, 42, 49, 56, 63, 70, 77, 84, and 91. Different letters (a, b) at a study day indicate significant differences among groups ( $P < .05$ ; Kruskal-Wallis and Mann-Whitney tests used sequentially).



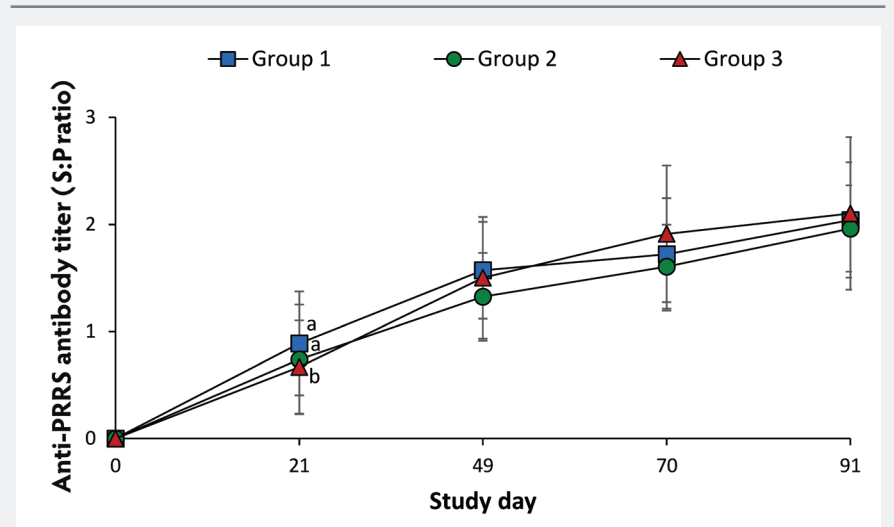
## Discussion

The results of this study demonstrate that under field conditions, in pigs vaccinated with MLV vaccines for PRRS, growth performance was better and lung lesions were fewer than in nonvaccinated controls. In addition, no significant differences between two commercial MLV PRRSV vaccines were found in this study, as determined by four types of outcomes: clinical (ADG and clinical signs), immunologic (antibodies), virologic (PCR testing), and pathologic (lesions and viral antigen). Measurement of PRRSV viremia was one of the parameters in assessing the efficacy of PRRS vaccines under an experimental challenge study.<sup>12-14</sup> However, in contrast to previous studies,<sup>15-17</sup> in the current study, under field conditions, the number of genomic copies of type 2 PRRS field virus RNA did not differ between vaccinated and nonvaccinated pigs. This difference may be due to varying conditions, such as ventilation and feeding systems, in experimental and field studies. In this field study, vaccinated and nonvaccinated pigs were housed in separate pens within the same barn. Therefore, vaccinated pigs could have been exposed to the circulating PRRS field virus. This might explain why the number of genomic copies of type 2 PRRS field virus RNA did not differ significantly between vaccinated and nonvaccinated pigs.

Although reproductive failure had occurred within 4 months of this study on the sow farms, maternally derived anti-PRRSV antibodies were not detected in any pigs from the three groups. In the 15 sows used in this study, PRRSV ELISA S:P ratios were low (0.4 to 0.7), suggesting that the majority of newborn piglets might have received small quantities of colostral anti-PRRSV antibodies from their dams. These passively acquired antibodies might decay in pigs by 21 days of age, which could explain why the 21-day-old pigs in this study had no detectable maternally derived anti-PRRSV antibodies at the time of vaccination.

Comparison of two commercial MLV PRRS vaccines provides swine practitioners and producers with clinical information concerning control of PRRSV infection. Regardless of the commercial MLV PRRS vaccine, growth performance was better and lung lesions were fewer in vaccinated pigs than in nonvaccinated pigs. However, there were no significant differences in growth performance or lung lesions between pigs vaccinated with either commercial MLV PRRS vaccine.

**Figure 2:** Mean anti-PRRSV antibody serum titers (with standard deviation) of pigs in the study described in Table 1. Blood samples were collected from pigs for serological testing at study days 0, 21, 49, 70, and 91 (PRRS ELISA; Idexx Laboratories, Inc, Westbrook, Maine; sample-to-positive [S:P] ratios reported). Different letters (a, b) at a study day indicate significant differences among groups ( $P < .05$ ; Tukey's multiple comparisons test).



**Table 2:** Means (standard deviation) of pulmonary lesion score and numbers of pulmonary cells positive for type 2 porcine reproductive and respiratory syndrome virus (PRRSV) nucleic acid\*

Group (n)	Vaccination† (21 days)	Lung	
		Lesion score‡	No. of type 2 PRRSV-positive cells§
1 (30)	Fostera PRRS	0.69 (0.51) <sup>a</sup>	3.33 (1.35)
2 (30)	Ingelvac PRRS MLV	0.81 (0.53) <sup>a</sup>	3.94 (1.85)
3 (30)	None	1.64 (0.44) <sup>b</sup>	4.17 (2.16)

\* Study described in Table 1.

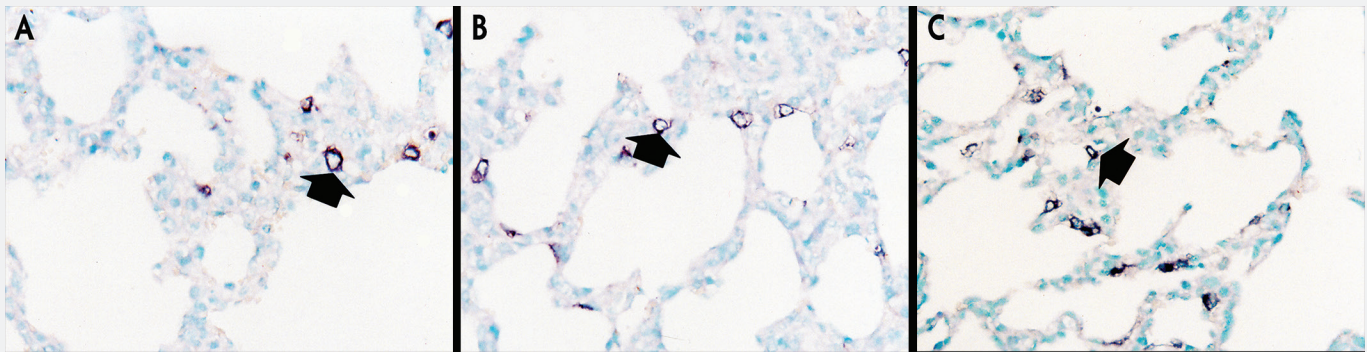
† Vaccines: Fostera PRRS: Zoetis, Florham, New Jersey and Ingelvac PRRS MLV; Boehringer Ingelheim Inc, St Joseph, Missouri.

‡ Lung samples were collected from pigs in each group at study day 147 (168 days of age). Eight pieces of lung tissue (two from the right cranial lobe, two from the right middle lobe, one from the ventromedial part of the right caudal lobe, one from the dorso-medial part of the right caudal lobe, one from the mid-lateral part of the right caudal lobe, and one from the accessory lobe) were collected from each pig, and three tissue sections from each of the eight lung pieces were examined blindly. Lung lesions were scored on a scale from 0 to 4: 0 = no microscopic lesions; 1 = mild interstitial pneumonia; 2 = moderate multifocal interstitial pneumonia; 3 = moderate diffuse interstitial pneumonia; and 4 = severe interstitial pneumonia. Scores were compared between groups using the Kruskal-Wallis and the Mann-Whitney tests sequentially.

§ Numbers of lung cells positive for type 2 PRRSV nucleic acid per unit area (0.25 mm<sup>2</sup>) of lung were counted using an NIH ImageJ 1.45s program (<http://imagej.nih.gov/ij/download.html>). Numbers of positive cells were compared between groups using a Tukey's multiple comparisons test.

<sup>ab</sup> Within a column, values with different superscript letters are significantly different ( $P < .05$ ).

**Figure 3:** In situ hybridization testing was performed using a type 2 PRRSV-specific probe to detect type 2 PRRSV nucleic acid in lungs of pigs in the study described in Table 1. Few type 2 PRRSV nucleic acid-positive cells (arrows) were detected in macrophages in pigs from Group 1 (Panel A), Group 2 (Panel B), or Group 3 (Panel C) (magnification  $\times 200$ ).



## Implications

- Under the conditions of this study in a PRRS-positive herd, growth performance and lung lesions do not differ between pigs vaccinated with either of two commercial PRRS vaccines.
- Efficacies of MLV PRRS vaccines are independent of the genetic similarity between the MLV PRRS and wild-type virus.

## Acknowledgements

This research was supported by contract research funds of the Research Institute for Veterinary Science from the College of Veterinary Medicine and by BK 21 PLUS Program for Creative Veterinary Science Research in the Republic of Korea. The first two authors contributed equally to this work.

## Conflict of interest

None reported.

## Disclaimer

Scientific manuscripts published in the *Journal of Swine Health and Production* are peer reviewed. However, information on medications, feed, and management techniques may be specific to the research or commercial situation presented in the manuscript. It is the responsibility of the reader to use information responsibly and in accordance with the rules and regulations governing research or the practice of veterinary medicine in their country or region.

## References

1. Snijder EJ, Meulenbergh JJM. The molecular biology of arteriviruses. *J Gen Virol.* 1998;79:961–979.
2. Murtaugh MP, Elam MR, Kakach LT. Comparison of the structural protein coding sequences of the VR-2332 and Lelystad virus strains of the PRRS virus. *Arch Virol.* 1995;140:1451–1460.
3. Nelsen CJ, Murtaugh MP, Faaberg KS. Porcine reproductive and respiratory syndrome virus comparison: divergent evolution on two continents. *J Virol.* 1999;73:270–280.
4. Zimmerman JJ, Benfield DA, Dee SA, Murtaugh MP, Stadejek T, Stevenson GW, Torremorell M. Porcine reproductive and respiratory syndrome virus (porcine arterivirus). In: Zimmerman JJ, Karriker LA, Ramirez A, Schwartz KJ, Stevenson GW, eds. *Diseases of Swine*. 10<sup>th</sup> ed. Ames, Iowa: Wiley-Blackwell; 2012:461–486.
5. Chow SC, Wang H, Shao J. Comparing means. In: Chow SC, Wang H, Shao J, eds. *Sample Size Calculations in Clinical Research*. 2<sup>nd</sup> ed. New York: Chapman & Hall/CRC; 2008:60–92.
6. Halbur PG, Paul PS, Frey ML, Landgraf J, Eernisse K, Meng X-J, Lum MA, Andrews JJ, Rathje JA. Comparison of the pathogenicity of two US porcine reproductive and respiratory syndrome virus isolates with that of the Lelystad virus. *Vet Pathol.* 1995;32:648–660.
7. Wasilk A, Callahan JD, Christopher-Hennings J, Gay TA, Fang Y, Dammen M, Reos ME, Torremorell M, Polson D, Mellencamp M, Nelson E, Nelson WM. Detection of U.S., Lelystad, and European-like porcine reproductive and respiratory syndrome viruses and relative quantitation in boar semen and serum samples by real-time PCR. *J Clin Microbiol.* 2004;42:4453–4461.
8. Park C, Seo HW, Han K, Kang I, Chae C. Evaluation of the efficacy of a new modified live porcine reproductive and respiratory syndrome virus (PRRSV) vaccine (Fostera PRRS) against heterologous PRRSV challenge. *Vet Microbiol.* 2014;172:432–442.
9. Han K, Seo HW, Park C, Chae C. Vaccination of sows against type 2 Porcine Reproductive and Respiratory Syndrome Virus (PRRSV) before artificial insemination protects against type 2 PRRSV challenge but does not protect against type 1 PRRSV challenge in late gestation. *Vet Res.* 2014;45:12. doi: 10.1186/1297-9716-45-12.
10. Do DT, Park C, Choi K, Jeong J, Nguyen TT, Le DTH, Vo KM, Chae C. Nucleotide sequence analysis of Vietnamese highly pathogenic porcine reproductive and respiratory syndrome virus from 2013 to 2014 based on the NSP2 and ORF5 coding regions. *Arch Virol.* 2016;161:669–675.
11. Halbur PG, Paul PS, Frey ML, Landgraf J, Eernisse K, Meng X-J, Andrews JJ, Lum MA, Rathje JA. Comparison of the antigen distribution of two US porcine reproductive and respiratory syndrome virus isolates with that of the Lelystad virus. *Vet Pathol.* 1996;33:159–170.
12. van Woensel PAM, Liefkens K, Demaret S. Effect on viraemia of an American and a European serotype PRRSV vaccine after challenge with European wild-type strains of the virus. *Vet Rec.* 1998;142:510–512.
13. Roca M, Gimeno M, Bruguera S, Segalés J, Díaz I, Galindo-Cardiel IJ, Martínez E, Darwich L, Fang Y, Maldonado J, March R, Mateu E. Effect of challenge with a virulent genotype II strain of porcine reproductive and respiratory syndrome virus on piglets vaccinated with an attenuated genotype I strain vaccine. *Vet J.* 2003;193:92–96.
14. Díaz I, Darwich L, Pappaterra G, Pujols J, Mateu E. Different European-type vaccines against porcine reproductive and respiratory syndrome virus have different immunological properties and confer different protection to pigs. *Virology.* 2006;351:249–259.
15. Martelli P, Gozio S, Ferrari L, Rosina S, De Angelis E, Quintavalla C, Bottarelli E, Borghetti P. Efficacy of a modified live porcine reproductive and respiratory syndrome virus (PRRSV) vaccine in pigs naturally exposed to a heterologous European (Italian cluster) field strain: Clinical protection and cell-mediated immunity. *Vaccine.* 2009;27:3788–3799.
16. Mavromatis I, Kritas SK, Alexopoulos C, Tsinas A, Kyriakis SC. Field evaluation of a live vaccine against porcine reproductive and respiratory syndrome in fattening pigs. *J Vet Med B.* 1999;46:603–612.
17. Park C, Seo HW, Kang I, Jeong J, Choi K, Chae C. A new modified live porcine reproductive and respiratory syndrome vaccine improves growth performance in pigs under field conditions. *Clin Vaccine Immunol.* 2014;21:1350–1356.



# Fact sheets – considerations regarding marketing heavy-weight pigs, and high-fiber ingredient withdrawal strategy before slaughter in finishing pigs

Márcio A. D. Gonçalves, DVM, PhD; Steve S. Dritz, DVM, PhD; Mike D. Tokach, MS, PhD; Joel M. DeRouchey, MS, PhD; Jason C. Woodworth, MS, PhD; Robert D. Goodband, MS, PhD

This practice tip includes fact sheets on marketing heavy-weight pigs and withdrawal of high-fiber ingredients before slaughter

**Keywords:** swine, market weight, market pig, fibrous ingredients

**Received:** July 24, 2015

**Accepted:** April 28, 2016

## Conflict of interest

None reported.

## Disclaimer

Scientific manuscripts published in the *Journal of Swine Health and Production* are peer reviewed. However, information on medications, feed, and management techniques may be specific to the research or commercial situation presented in the manuscript. It is the responsibility of the reader to use information responsibly and in accordance with the rules and regulations governing research or the practice of veterinary medicine in their country or region.

---

MADG, SSD: Department of Diagnostic Medicine/Pathobiology, College of Veterinary Medicine, College of Agriculture, Kansas State University, Manhattan, Kansas.

MDT, JMDR, JCW, RDG: Department of Animal Sciences and Industry, College of Veterinary Medicine, College of Agriculture, Kansas State University, Manhattan, Kansas.

**Corresponding author:** Dr Márcio A. D. Gonçalves, Department of Diagnostic Medicine/Pathobiology, College of Veterinary Medicine, Kansas State University, Manhattan, Kansas.

Dr Gonçalves is currently with Genus PIC PLC, 100 Bluegrass Commons Blvd, Suite 2200, Hendersonville, TN 37075; Tel: 615-265-2729; Fax: 615-265-2848; E-mail: [Marcio.Goncalves@GenusPLC.com](mailto:Marcio.Goncalves@GenusPLC.com).

This article was published as part of Dr Gonçalves' PhD thesis, Kansas State University, Manhattan, Kansas; 2015.

This article is available online at <http://www.aasv.org/shap.html>.

Gonçalves MAD, Dritz SS, Tokach MD, et al. Fact sheets – considerations regarding marketing heavy-weight pigs, and high-fiber ingredient withdrawal strategy before slaughter in finishing pigs. *J Swine Health Prod.* 2017;25(1):29–33.

# FACT Sheet: Considerations regarding marketing heavy-weight pigs

Market weight has linearly increased by 5.8 kg every 10 years during the last four decades.<sup>1</sup> This trend is driven by the dilution of fixed costs over more weight per pig and improvement in genetics and nutrition that result in more efficient and leaner pigs at heavier body weights than in previous years.<sup>1</sup> Because market weight has been increasing linearly, the definition of “heavy” market weight is dynamic. Currently, heavy market weight could be defined as a group average of above 130 kg.

Average daily gain (ADG) is expected to be 0.5% to 1.5% lower in pigs fed to 145 kg body weight (BW), compared to those fed to 125 kg BW.<sup>2,3</sup> Space allowance is one of the main factors that will limit gain when pigs get heavier. Similarly, feed efficiency is expected to worsen by 4% to 9% when average final weight increases from approximately 125 to 145 kg.<sup>2-5</sup> Also, as body weight increases, a slight increase in carcass yield has been reported.<sup>6,7</sup>

## Genetic considerations

Different genetic lines will perform differently when raised to heavier market weights, probably due to differences in lean and fat deposition.<sup>2,4,8</sup> For instance, a Spanish study<sup>8</sup> has shown that market pigs sired by three different terminal boar lines showed up to a 3.6% difference in performance for ADG and a 4.0% difference in feed-to-gain (F:G) at the time of marketing (130 kg).

## Nutritional considerations

More nutrient requirement information is needed. Factorial approaches have been used to estimate amino-acid requirements for heavy-weight pigs.<sup>3</sup> As an example, the estimates for the standardized ileal digestible (SID) lysine (Lys) requirements for pigs fed from 125 to 140 kg<sup>3</sup> and from 140 to 160 kg<sup>9</sup> were 0.56% and 0.51%, respectively. However, there is no body of empirical studies in these weight ranges to increase confidence in these modeled estimates. Other examples include the nutrient requirements when feeding ractopamine. Hot carcass weight was higher in pigs fed ractopamine up to 130 kg BW,<sup>10</sup> suggesting that ractopamine is still effective at higher market weights. The National Research Council (NRC) model<sup>3</sup> estimates the SID Lys requirement from 125 to 140 kg BW is 0.77% when using 10 g of ractopamine per ton; however, again, there is a need for empirical studies to confirm this estimate.

## Health considerations

Assuming the same rate per day in mortality, a longer feeding period will incur a slight increase in mortality. In addition, increased risk for lateral infections and loss of additional heavy-weight pigs will increase the overall F:G of a barn due to the amount of feed consumed.<sup>11</sup> Additionally, depending on the time during the finishing period when diseases are occurring, and the duration of vaccine immunity, adding 2 to 4 weeks until harvest, may require altered vaccination strategies.<sup>12</sup>

## Fast facts

Adequate pen space and marketing strategies are crucial to maximize the value of heavier market-weight pigs.

New facilities and equipment (feeder space, drinker height, gate height, alley width, loading ramp) must account for heavier market weight.

There is a need for more empirical data on nutrient requirements of heavier-weight pigs.

## Management considerations

Pen space and marketing strategy are key factors when marketing heavy-weight pigs. If pen space is limited, feed intake, and thus growth, will decrease. Compared to a market weight of 120 kg, space allowance requirements increase 5% per pig for 130 kg BW or 11% for 140 kg BW.<sup>13</sup> A 136-kg market weight requires 0.90 m<sup>2</sup> per pig for maximum ADG, while 0.77 m<sup>2</sup> per pig causes a 5% reduction in ADG.<sup>13</sup> Strategies that market pigs at regular intervals before closing out a barn provide more space for remaining pigs and allows them to increase their growth. For example, removing pigs to increase space allowance from 0.65 to 0.84 m<sup>2</sup> per pig over the last 3 weeks before reaching market weight (140 kg) increased growth rate by 4.8%.<sup>14</sup>

Heat production and ventilation will be affected when marketing heavy-weight pigs.<sup>15</sup> Pigs produce approximately 8% more heat for each 10-kg increase in BW.<sup>15</sup> It is estimated that from 110 to 132 kg BW, there is approximately a 15% increase in heat production per pig.<sup>1</sup> The recommended air flow in the barn is 19.9 m<sup>3</sup> per hour per 115-kg pig, 22.1 m<sup>3</sup> per hour per 127-kg pig, and 24.3 m<sup>3</sup> per hour per 138-kg pig. Thus, ventilation rate increases with increased market weight on a per-pig basis; however, at the barn level, ventilation may not change dramatically if the production system is marketing pigs at regular intervals before closing out the barn.

Adding 4 extra weeks of growth (ie, 125 to 145 kg) could potentially increase the proportion of gilts that would present with pubertal estrus.<sup>16</sup> This could have a modest impact on feed intake and ease of handling market gilts.

Transportation is another factor to be taken into consideration when marketing heavy-weight pigs. Heavier pigs require more space during transport to maintain welfare and reduce transport losses.<sup>17</sup> Thus, the recommended space allowance on trucks for pigs marketed in the summer is 0.46 m<sup>2</sup> per pig at 114 kg BW, 0.55 m<sup>2</sup> per pig at 136 kg BW, or 0.65 m<sup>2</sup> per pig at 182 kg BW.<sup>17</sup> Therefore, fewer pigs will be marketed in each load as pig body weight increases.

## Facility and equipment design considerations

Due to continued trends for increased body weight of pigs at marketing, building designs should account for this change. Heavier pigs are wider and taller; thus, feeder space, drinker height, gate height, and alley width must be carefully considered.

The amount of feeder space needed is normally 1.1 times shoulder width.<sup>1</sup> Because shoulder width increases from 31.5 to 32.7 cm when pigs grow from 125 to 140 kg BW,<sup>18</sup> the requirement for width of a feeder space increases from 34.7 to 36.0 cm.

For a 140-kg BW pig, drinker height should be approximately 77 cm for a 90-degree nipple drinker and 92 cm for a downward-mounted nipple drinker.<sup>19</sup> However, the drinker height should be adjusted to the shoulder height of the smallest pig in the pen.<sup>19</sup> Shoulder height increases by 2.8 cm when pigs grow from 125 to 140 kg BW,<sup>19</sup> therefore, gate height might be a factor to be taken into consideration when building new facilities. Finally, for pigs heavier than 125 kg, 15 degrees or less is the recommended loading-ramp angle, compared to 20 degrees for lighter pigs.<sup>17</sup>

## Packing plant considerations

Factors associated with marketing heavy-weight pigs that can have an impact in the packing plant are rail capacity, rail height, primal cut size, and cooling capacity. Pigs could be heavier than the facility is designed for; thus, the amount of weight that rails support may be a limiting factor. Increased length of the carcass could pose a challenge for food safety if the rail is not high enough. Increased primal cut size will require adjustment of cut sizes from the retail market perspective. Similarly, increased weight will require an extra amount of cooling time for the carcass; thus, a different cooling-time strategy may be required.

## Acknowledgement

Contribution no. 16-008-J from the Kansas Agricultural Experiment Station, Manhattan, KS 66506-0210.

## References

- \*1. Brumm M. Impact of heavy market weights on facility and equipment needs. *Proc Allen D. Leman Swine Conf.* St Paul, Minnesota. 2012;165–168.
- \*2. Jungst S, Matthews N, Booher C, Fields B, Dreadin T, Tabor S, Anderson J, Martin J, Williams A, Jobin M, Sosnicki A, Wilson E. Growth curves for commercial PIC337RG pigs fed high and low energy diets. PIC Tech Memo. Hendersonville, Tennessee. 2012;ES51-344. Available at <http://www.pic.com/Images/Users/1/SalesPortal/ExecutiveSummaries/ES051.pdf>. Accessed 18 October 2016.
3. NRC. Model for estimating nutrient requirements of swine. In: *Nutrient Requirements of Swine*. 11<sup>th</sup> rev ed. Washington, DC: National Academy Press; 2012:127–156.
- \*4. Jungst S, Matthews N, Booher C, Fields B, Dreadin T, Tabor S, Anderson J, Martin J, Williams A, Jobin M, Sosnicki A, Wilson E. Growth curves for PIC327L sired pigs fed diets with differing energy levels. PIC Tech Memo. Hendersonville, Tennessee. 2012;ES50-344.(5) 6. Available at <http://www.pic.com/Images/Users/1/SalesPortal/ExecutiveSummaries/ES050.pdf>. Accessed 18 October 2016.

5. Latorre MA, Lázaro R, Valencia DG, Medel P, Mateos GG. The effects of gender and slaughter weight on the growth performance, carcass traits, and meat quality characteristics of heavy pigs. *J Anim Sci.* 2004;82:526–533.
6. Virgili R, Degni M, Schivazappa C, Faeti V, Poletti E, Marchetto G, Pacchioli MT, Mordenti A. Effect of age at slaughter on carcass traits and meat quality of Italian heavy pigs. *J Anim Sci.* 2003;81:2448–2456.
7. Apple JK, Maxwell CV, Galloway DL, Hutchison S, Hamilton CR. Interactive effects of dietary fat source and slaughter weight in growing-finishing swine: I. Growth performance and longissimus muscle fatty acid composition. *J Anim Sci.* 2009;87:1407–1422.
8. Latorre MA, Medel P, Fuentetaja A, Lázaro R, Mateos GG. Effect of gender, terminal sire line and age at slaughter on performance, carcass characteristics and meat quality of heavy pigs. *Anim Sci.* 2003;77:33–46.
9. Manini R, Piva A, Prandini A, Mordenti A, Piva G, Dourmad JY. Protein retention in Italian heavy pigs: Development of a factorial approach for the determination of lysine requirement. *Livest Prod Sci.* 1997;47:253–259.
10. Fernández-Dueñas DM, Myers AJ, Scramlin SM, Parks CW, Carr SN, Killefer J, McKeith FK. Carcass, meat quality, and sensory characteristics of heavy body weight pigs fed ractopamine hydrochloride (Paylean). *J Anim Sci.* 2008;86:3544–3550.
11. Dritz SS. Influence of health on feed efficiency. In: Patience J, ed. *Feed Efficiency in Swine*. Wageningen, The Netherlands: Wageningen Academic Publishers; 2012:225–237.
12. Roth JA, Thacker EL. Immune system. In: Straw B, Zimmerman J, D’Allaire S, Taylor DJ, eds. *Disease of Swine*: 9<sup>th</sup> ed. Ames, Iowa: Blackwell Publishing; 2006:15–35.
13. Gonyou HW, Brumm MC, Bush E, Deen J, Edwards SA, Fangman T, McGlone JJ, Meunier-Salaun M, Morrison RB, Spooler H, Sundberg PL, Johnson AK. Application of broken-line analysis to assess floor space requirements of nursery and grower-finisher pigs expressed on an allometric basis. *J Anim Sci.* 2006;84:229–235.
- \*14. Flohr JR, Tokach MD, Dritz SS, Woodworth JC, DeRouchey JM, Goodband RD. Using meta-analyses to generate alternative prediction equations for the space requirements of finishing pigs. Kansas State University Agricultural Experiment Station and Cooperative Extension Service. 2015;1:39.
15. Brown-Brandt TM, Nienaber JA, Xin H, Gates RS. A literature review of swine heat production. *Trans ASAE.* 2004;47:259–270.
16. Tummaruk P, Tantasuparuk W, Techakumphu M, Kunavongkrit A. The association between growth rate, body weight, backfat thickness and age at first observed oestrus in crossbred Landrace × Yorkshire gilts. *Anim Reprod Sci.* 2009;110:108–122.
- \*17. Grandin T. Welfare of pigs during transport. Pork Information Gateway. 2002. Available at <http://porkgateway.org/resource/welfare-of-pigs-during-transport/>. Accessed 10 October 2016.
18. Petherick JC. A biological basis for the design of space in livestock housing. In: Baxter SH, Baxter MR, MacCormack JASC, eds. *Farm Animal Housing and Welfare*. Boston, Massachusetts: Martinus Nijhoff Publisher; 1983:103.
- \*19. Gonyou HW. Water use and drinker management. Prairie Swine Centre, Saskatoon. 1996. Available at <http://www.prairieswine.com/pdf/1311.pdf>. Accessed 22 September 2016.

\* Non-refereed references.



# FACT Sheet: High-fiber ingredient withdrawal strategy before slaughter in finishing pigs

It is often economically viable to use high-fiber ingredients such as distillers dried grains with solubles (DDGS) and wheat middlings in finishing pig diets. Because most swine producers are paid on a carcass basis, it is important to understand the impact of high-fiber ingredient diets on carcass characteristics and economics. Feeding high-fiber ingredient diets up to market has been shown to reduce carcass yield due to increased gut fill and visceral weight.<sup>1</sup> Many high-fiber ingredients contain unsaturated fatty acids, which also increases iodine value (IV).<sup>1</sup>

## What is high-fiber ingredient withdrawal?

High-fiber ingredient withdrawal is the replacement of the high-fiber ingredients in finishing diets by low-fiber ingredient(s) (eg, a diet based on corn and soybean meal) for a specific time before market.

## Impact of high-fiber ingredient withdrawal on carcass yield and carcass weight

Carcass yield is lower in pigs fed high-fiber ingredient diets until market than in pigs fed a diet based on corn and soybean meal.<sup>2,3</sup> Carcass yield is restored after 15 to 51 days withdrawal of the high-fiber ingredients, becoming comparable to carcass yield when a corn-soybean meal diet is fed.<sup>2-6</sup> The lower carcass yield is a result of increased large intestine weight and fecal volume when pigs are fed a diet high in insoluble fiber.<sup>7,8</sup> Because yield is the ratio between carcass and live weight, an increase in live weight without a change in carcass weight leads to a lower yield. A descriptive summary of eight experiments<sup>8</sup> in which high-fiber ingredient diets were fed for periods of varying durations suggests an increase of 0.16% in carcass yield for each 1% reduction in neutral detergent fiber. The negative impact on carcass yield of feeding high-fiber ingredient diets until market is reported to be greater in immunocastrated than in physically castrated pigs.<sup>5</sup>

## Impact of high-fiber ingredient withdrawal on carcass fat quality

Iodine value is a practical means of measuring unsaturated (“soft”) fat, by measuring the relative number of double bonds in the fatty acids. More unsaturated dietary fat is associated with a higher carcass fat IV. From a dietary fat perspective, linoleic acid (C18:2n-6) and  $\alpha$ -linoleic acid (C18:3n-3) are the main drivers of higher IV.<sup>9</sup> Therefore, withdrawing feeding ingredients such as DDGS and wheat middlings, which have higher levels of unsaturated fatty acids (ie, linoleic acid) will reduce the amount of unsaturated fat in the carcass and consequently reduce IV. Iodine value was linearly improved with up to 20 days withdrawal of the high-fiber ingredients, but this was not long enough to fully restore IV.<sup>8</sup> However, IV value was fully restored by using a 9-week withdrawal of high-fiber ingredients.<sup>10</sup> Conversely, withdrawal of high-fiber ingredients that contain no unsaturated fatty acids is not expected to influence IV value.

## Fast facts

High-fiber diets fed until market reduce carcass yield.

Many high-fiber ingredients also contain high concentrations of unsaturated fatty acids which can increase carcass fat iodine value.

High-fiber ingredient withdrawal of approximately 15 to 20 days is able to restore carcass yield and reduce impact on iodine value.

If high-fiber ingredient diets are economical, a high-fiber ingredient withdrawal of 15 to 20 days prior to market maximizes income over feed cost across different market scenarios.

## High-fiber-ingredient withdrawal time to mitigate negative yield effects

Two recent studies evaluated withdrawal of high-fiber ingredients in diets with 30% DDGS and 19% wheat middlings for 5, 10, 15, and 20 days (Experiment 1) and 9, 14, 19, and 24 days (Experiment 2) before market.<sup>8</sup> In Experiment 1, carcass yield of pigs marketed on the same day was restored in a quadratic manner with increase in high-fiber ingredient withdrawal time, being fully restored at 15 days. In Experiment 2, hot carcass weight of pigs marketed on the same day was linearly increased when high-fiber ingredient withdrawal time was increased. The data suggested a high-fiber ingredient withdrawal time of approximately 15 to 20 days is needed to fully restore carcass yield.<sup>8</sup>

## Impact of high-fiber ingredient withdrawal on economic performance

Economic calculations have demonstrated<sup>8</sup> that when feeding high-fiber diets, a high-fiber ingredient withdrawal period of approximately 15 to 20 days maximized income over feed cost across widely variable ingredient and pork market prices. In those scenarios, the benefits ranged from \$2.20 to \$2.90 per pig (all currency in \$US).<sup>8</sup> High-fiber ingredient withdrawal was modeled to be more economical independent of the production flow (ie, fixed weight or fixed time basis).<sup>8</sup> The economics are driven by pigs fed a low-fiber ingredient diet maintaining feed intake while consuming a more calorie-dense diet, which leads to improved carcass weight relative to live weight.

## Acknowledgement

Contribution no. 16-006-J from the Kansas Agricultural Experimental Station, Manhattan, KS 66506-0210.



## References

1. Salyer JA, DeRouchey JM, Tokach MD, Dritz SS, Goodband RD, Nelssen JL, Petry DB. Effects of dietary wheat middlings, distillers dried grains with solubles, and choice white grease on growth performance, carcass characteristics, and carcass fat quality of finishing pigs. *J Anim Sci.* 2012;90:2620–2630.
  - \*2. Gaines AM, Spencer JD, Petersen GI, Augspurger NR. Effect of corn distiller's dried grains with solubles (DDGS) withdrawal program on growth performance and carcass yield in grow-finish pigs [abstract]. *J Anim Sci.* 2007;85:438.
  - \*3. Jacela JY, Benz JM, Dritz SS, Tokach MD, DeRouchey JM, Goodband RD, Nelssen JL, Prusa KJ. Effect of dried distillers grains with solubles (DDGS) withdrawal regimens on finishing pig performance and carcass traits [abstract]. *J Anim Sci.* 2010;88:53.
  4. Asmus MD, DeRouchey JM, Tokach MD, Dritz SS, Houser TA, Nelssen JL, Goodband RD. Effects of lowering dietary fiber before marketing on finishing pig growth performance, carcass characteristics, carcass fat quality, and intestinal weights. *J Anim Sci.* 2014;92:119–128.
  5. Asmus MD, Tavarez MA, Tokach MD, Dritz SS, Schroeder AL, Nelssen JL, Goodband RD, DeRouchey JM. The effects of immunological castration and corn dried distillers grains with solubles withdrawal on growth performance, carcass characteristics, fatty acid analysis, and iodine value of pork fat depots. *J Anim Sci.* 2014;92:2116–2132.
  6. Nemechek JE. Effects of pelleting and dietary fat and fiber levels on pig growth and fat quality [PhD dissertation]. Manhattan, Kansas: Kansas State University. 2014:121.
  7. Graham AB, Goodband RD, Tokach MD, Dritz SS, DeRouchey JM, Nitikanchana S. The interactive effects of high-fat, high-fiber diets and ractopamine HCl on finishing pig growth performance, carcass characteristics, and carcass fat quality. *J Anim Sci.* 2014;92:4585–4597.
  - \*8. Coble K, DeRouchey JM, Tokach MD, Dritz SS, Goodband RD, Woodworth JC. The importance of implementing a by-product withdrawal strategy prior to slaughter in finishing pigs: A review of strategies that mitigate the negative impact on carcass yield [abstract]. *J Anim Sci.* 2015;93:48.
  9. Paulk CB. Predicting market pig weights and fat iodine value and effect of zinc on growth performance and immune function of finishing pigs [PhD dissertation]. Manhattan, Kansas: Kansas State University. 2014:171.
  10. Xu G, Baidoo SK, Johnston LJ, Bibus D, Cannon JE, Shurson GC. The effects of feeding diets containing corn distillers dried grains with solubles, and withdrawal period of distillers dried grains with solubles, on growth performance and pork quality in grower-finisher pigs. *J Anim Sci.* 2010;88:1388–1397.
- \* Non-refereed references.



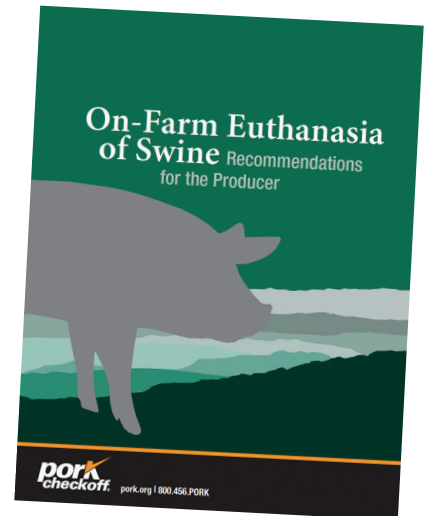


## Checkoff unveils updated on-farm euthanasia guide

The newly revised *On-Farm Euthanasia of Swine Recommendations for the Producer* (English and Spanish), produced by the Pork Checkoff and the American Association of Swine Veterinarians, is now available in both print and electronic versions. According to Sherrie Webb, Checkoff's director for animal welfare, the changes to the guide were made in light of new research data on various euthanasia methods, many of which were found through Pork Checkoff-funded work. These changes, along with field experience with the current commercially available equipment, allowed for fine tuning of the recommendations. Webb says notable changes include electrocution, which is now

acceptable for pigs older than 3 days of age, and the non-penetrating captive bolt, which is now acceptable as a single-step method for pigs up to 70 pounds, if the appropriate force is achieved. The timely euthanasia definition also was updated to be consistent with the Common Swine Industry Audit. Additional updates were made to streamline the guide to make it easier to read.

To get printed or electronic copies, go to [pork.org](http://pork.org) and click on the Pork Store button on the homepage. For more information, contact Sherrie Webb at [SWebb@pork.org](mailto:SWebb@pork.org) or 515-223-3533.



## US pig farmers celebrate progress on antibiotic stewardship

The National Pork Board recently celebrated the US Centers for Disease Control and Prevention's (CDC's) annual celebration, "Get Smart About Antibiotics Week," by highlighting recent activities related to using antibiotics wisely to safeguard the health and well-being of people, animals, and the environment.

"The 'Get Smart About Antibiotics Week' is a good time to reflect on our long history of accomplishments in the antibiotics area, such as using these medications responsibly and embracing the updated Pork Quality Assurance Plus certification program," said National Pork Board President Jan Archer, a pig farmer from North Carolina. "As pig farmers, we are aware of the challenge of antibiotic resistance and are dedicated to working hard to preserve the effectiveness of antibiotics, both on the farm and in human medicine."

The National Pork Board's three-point antibiotic stewardship plan, announced in

mid-2015, focuses on promoting research, increasing pig-farmer education and communicating with consumers in 2016 and beyond. The Antibiotic Resource Center, found at [www.pork.org/antibiotics](http://www.pork.org/antibiotics), is an example of efforts to assist farmers and others who want to learn more about responsible on-farm antibiotic use.

In another demonstration of its commitment to the complex issue of antibiotic resistance, the National Pork Board hosted a national dialogue earlier this year called "Resistance: The Antibiotic Challenge." The Washington, DC, event brought together key opinion leaders from human health, animal health, government, pharmaceutical, and retail and consumer segments to discuss the challenge of responsible antibiotic use in the 21<sup>st</sup> century. Another joint dialog occurred earlier this month in Denver when the National Pork Board and the American Public Health Association discussed the shared responsibility of reducing the need for antibiotics.

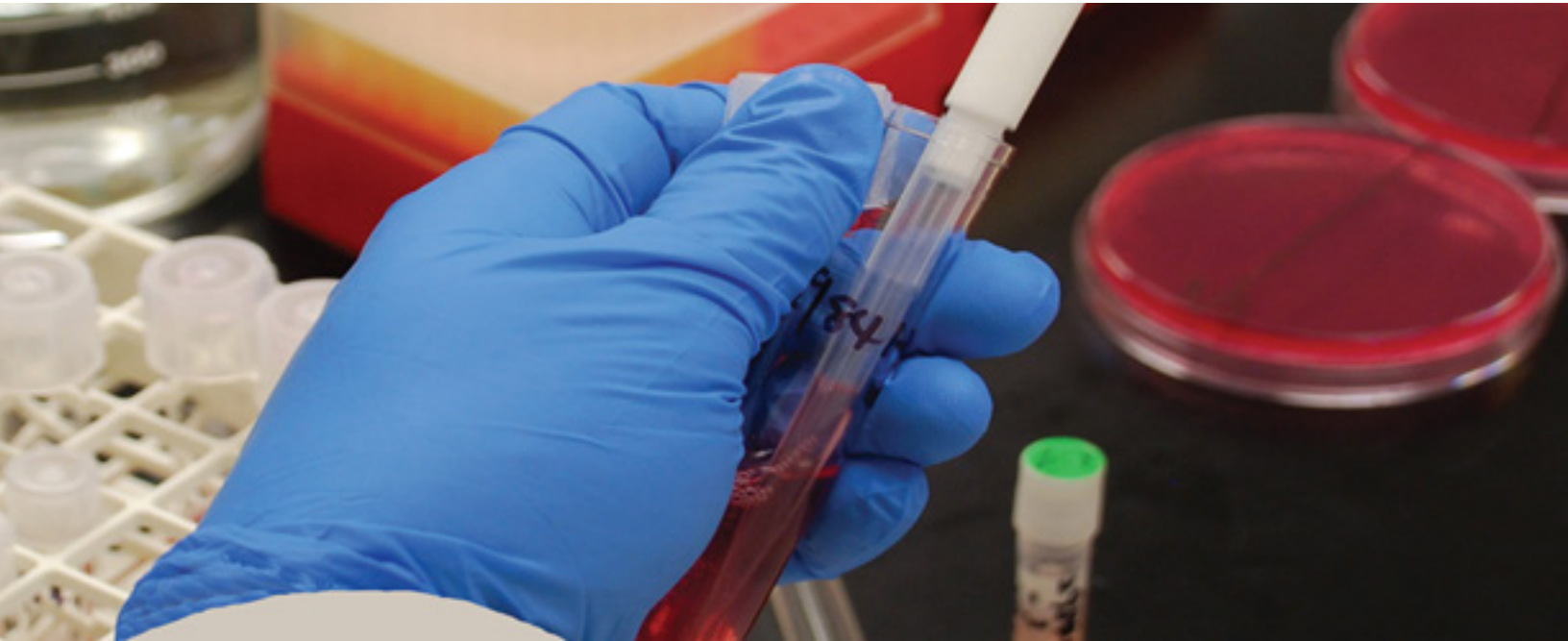
Financially, the farmer-led board has invested more than \$6 million in Pork Checkoff funds in antibiotic-related research since 2000, with \$750,000 spent this year alone in five research priority areas specifically aimed at reducing antibiotic resistance and finding antibiotic alternatives.

"Real change is underway on pig farms across America, with farmers and their veterinarians shaping the discussion around responsible antibiotic use," Archer said. "As the Food and Drug Administration prepares to implement the new, more stringent rules, such as the upcoming ban on using medically important antibiotics for growth promotion in food animals, we'll be ready."

For more information, contact Mike King, director of science communications, at [mking@pork.org](mailto:mking@pork.org) or 515-223-3532.

# Reliable Herd Health Solutions

Since 1981



## MVP Labs Now Part of Phibro Animal Health Corporation

### Tailor-Made<sup>®</sup> Autogenous BACTERIALS

- *Strep. suis*, *H. parasuis*, and *A. suis*
- *Mycoplasma hyopneumoniae*,  
*M. hyorhinis*, and *M. hyosynoviae*
- *Clostridium perfringens* (Types A & C)  
and *C. difficile*
- *E. coli*, *E. rhusiopathiae*, and  
*A. pleuropneumoniae*

### VIRAL VACCINES

- MJPRRS<sup>®</sup>
- SIV, PEDv, and PDCoV

Potency and efficacy of autogenous biologics have not been established

### Commercial Vaccines

- Emulsibac<sup>®</sup>-APP
- Bordetella Bronchiseptica Intranasal

### Diagnostic Services

- Trusted and Timely
- Vaccine-Focused

HEALTHY ANIMALS. HEALTHY FOOD. HEALTHY WORLD. <sup>®</sup>

# Pork Checkoff offers public-focused infographic on responsible antibiotic use

To help tell the real story of how today's pork producers are working with their veterinarians to do the right thing as it relates to antibiotic use, the National Pork Board has created an infographic to share with the public. It debuted during CDC's "Get Smart About Antibiotics Week" last November and is available as a poster or PDF via [pork.org](http://pork.org) and the Checkoff's Pork Store site at no charge.

For more information, contact Mike King, director of science communications, at [mking@pork.org](mailto:mking@pork.org) or 515-223-3532.

## Swine science online now available

You may have heard about the US Pork Center of Excellence's Swine Science Online program, but now there's an easy way for you to explain it to others – simply go to "TheUSPorkCenter" page on YouTube to view an overview of what the Swine Science Online program has to offer. Its purpose is to make sure students who are interested in the swine industry know about this opportunity so that it will expand their educational options and help improve the pork industry for the future. Swine Science Online is the perfect option for students looking to enhance their education or for pig farmers looking for specialization. It is 17 individual courses, with industry-leading instructors available to students across the county, no matter their current university or college.

For more information, contact Chelsey Van Genderen at [cvangenderen@usporkcenter.org](mailto:cvangenderen@usporkcenter.org) or 515-223-2641.

**RESPONSIBLE ANTIBIOTIC USE**  
on Today's Pig Farms  
Protects People, Pigs and Planet

**Doing the right thing**

The National Pork Board represents all of America's pig farmers whose No. 1 GOAL is to do the right thing for people, pigs and the planet. This includes using antibiotics responsibly, reducing the need to use them and preparing for new federal rules.

**Antibiotic Resistance**  
Just as human patients work with their medical doctors, America's pig farmers work with their veterinarians to help reduce antibiotic resistance. This is the ability of a microbe to grow in the presence of an antibiotic that would normally kill or limit the microbe's growth, which is not good for human, animal or environmental health.

**ANTIBIOTIC RESISTANCE**

1. Bacteria, including a resistant variety.
2. Antibiotics kill or inhibit most normal bacteria.
3. Resistant bacteria multiplies.
4. Infection becomes resistant to antibiotics.

Normal Bacteria, Resistant Bacteria, Dead/Inhibited Bacteria, Antibiotic

**ONE HEALTH UMBRELLA: Shared Responsibility, Opportunity to Combat Antibiotic Resistance**

The worldwide One Health approach to combat antibiotic resistance is critical to human and animal health. This is a collaborative effort to attain optimal health for people, domestic animals, wildlife and the environment. Medical doctors and patients, veterinarians and farmers, along with government, academia and industry stakeholders, are cooperating. Pig farmers play an important role in the shared effort to use antibiotics responsibly to help minimize the potential emergence of antibiotic-resistant bacteria.

**HEALTHY HUMANS**  
ALL PEOPLE

- Reduction of disease risk for humans
- Reduction in pandemic risk
- Improved public health globally

**HEALTHY ANIMALS**  
DOMESTIC AND WILD

- Reduction of disease risk for animals
- Reduction in pandemic risk
- Improved animal health and food safety

**HEALTHY PLANET**  
PLANTS AND ENVIRONMENT

- Ecosystem resilience
- Environmentally friendly approaches
- Includes entire natural habitat

**DID YOU KNOW**

- > As of 2017, implementation of the new FDA rules affects for **ALL FOOD-ANIMAL SPECIES**, including pigs. The National Pork Board will continue outreach and education to producers.
- > Pig farmers are building on **NEARLY 30 YEARS OF EXCELLENCE**, through the Pork Quality Assurance® program and an enhanced emphasis on responsible antibiotic use.
- > U.S. pig farmers have committed more than **\$6 MILLION TO ANTIBIOTIC RESEARCH SINCE 2000**.
- > **STOP** As of Jan. 1, 2017, antibiotics important to human medicine are **NO LONGER BE ALLOWED FOR GROWTH PROMOTION IN FOOD ANIMALS**.
- > **IN 2016, U.S. PIG FARMERS INVESTED \$750,000** in five research areas that include defining alternative antibiotic technologies, studying the environmental fate of antibiotics and better understanding the impact of antibiotic-resistant bacteria.

Pork Checkoff Service Center **1.800.456.7675**

**Pork Checkoff** ©2016 National Pork Board, Des Moines, IA USA. This message funded by America's Pork Checkoff Program.



Visit [pork.org/antibiotics](http://pork.org/antibiotics) for more information.

**#AntibioticSmart**  
**#RealPigFarming**  
**#CombatingAMR**

03050/11-16





**7 WEEKS DOI**  
COMPETITOR'S VACCINE



**20 WEEKS DOI**  
PORCILIS™ ILEITIS



# ILEITIS PROTECTION ALL THE WAY TO MARKET.

**LONG-LASTING PROTECTION FOR ILEITIS CONTROL.** With a 20-week DOI, vaccination with Porcilis™ Ileitis provides 13 more weeks of protection than the competitor vaccine. The only injectable vaccine in a single bottle, Porcilis Ileitis does not require any preparation, no mixing, and no risk of contamination.



**Porcilis™ Ileitis**

• LAWSONIA INTRACELLULARIS

**DRIVEN BY PREVENTION™**

[DrivenByPrevention.com](http://DrivenByPrevention.com)



Copyright © 2016 Intervet Inc., doing business as Merck Animal Health, a subsidiary of Merck & Co., Inc. All rights reserved. 9/16 SW-55418



# AASV NEWS

## Alternate Student Delegate selected for AASV Board

The AASV Student Recruitment Committee is pleased to announce the selection of Jordan Gebhardt (Kansas State University, 2019) as the incoming Alternate Student Delegate to the AASV Board of Directors.

Gebhardt grew up on a small family farm in Cedar Springs, Michigan, where he gained experience with feeder cattle and swine and assisted in the operations of his family's commercial feed mill. He entered a combined DVM-PhD program at Kansas State University and is currently progressing through his second year of the veterinary curriculum.

He has been involved in numerous organizations directly involved with promotion of agriculture and professional development of agriculture's future leaders. These organizations have included Alpha Gamma Rho, Michigan State University Block & Bridle Club, K-State CVM Class of 2019 Executive Board, as well as the K-State SCAASV. As president of the Kansas State University Swine Club, he directed an effort to provide interaction with the swine nutrition graduate students and AASV swine club students by holding joint educational activities, including wet labs at the K-State

swine farm, a speaker series involving many industry leaders from throughout the United States, and social activities. He has won the American Society of Animal Science student paper competitions as both an undergraduate and as a PhD student.

Gebhardt notes that he "decided to become involved with and take on leadership roles in these organizations for multiple reasons, but most importantly to be an active part in creating opportunities and developing the passion in others for what I am most passionate about, agriculture."

Gebhardt feels the alternate delegate position with AASV will be an excellent opportunity to further his involvement within the veterinary community, and, more importantly, will be an opportunity to continue promoting the industry and profession.

Gebhardt assumes his duties as Alternate Student Delegate during the 2017 AASV Annual Meeting in Denver. The current alternate delegate, Brent Sexton, will assume the delegate position currently held by Emily Mahan-Riggs who will rotate off the board. Brent and Jordan will represent student



interests within AASV as non-voting members of the board of directors and the Student Recruitment Committee.

Please join us in welcoming Jordan to the AASV Board of Directors and thanking Emily for her service!

## Veterinary Feed Directive (VFD) common form

The Food and Drug Administration has issued Guidance Document #233 (GFI #233, <http://www.fda.gov/downloads/AnimalVeterinary/GuidanceComplianceEnforcement/GuidanceforIndustry/UCM474640.pdf>) to describe a suggested common format for VFD forms. Drug

sponsors are required to provide a VFD form to FDA as part of the VFD drug approval process and make this form available for veterinary use following approval. Veterinarians, however, are not required to use the form provided by the drug sponsor and may create a form of their choosing as long as it contains

the required information. Guidance document #233 also provides guidance concerning the elements that must be included on the VFD and the elements that may be included on the VFD. In addition, Guidance document #233 provides examples of a suggested VFD format.

## Iowa State University and AASV publish VFD FAQs

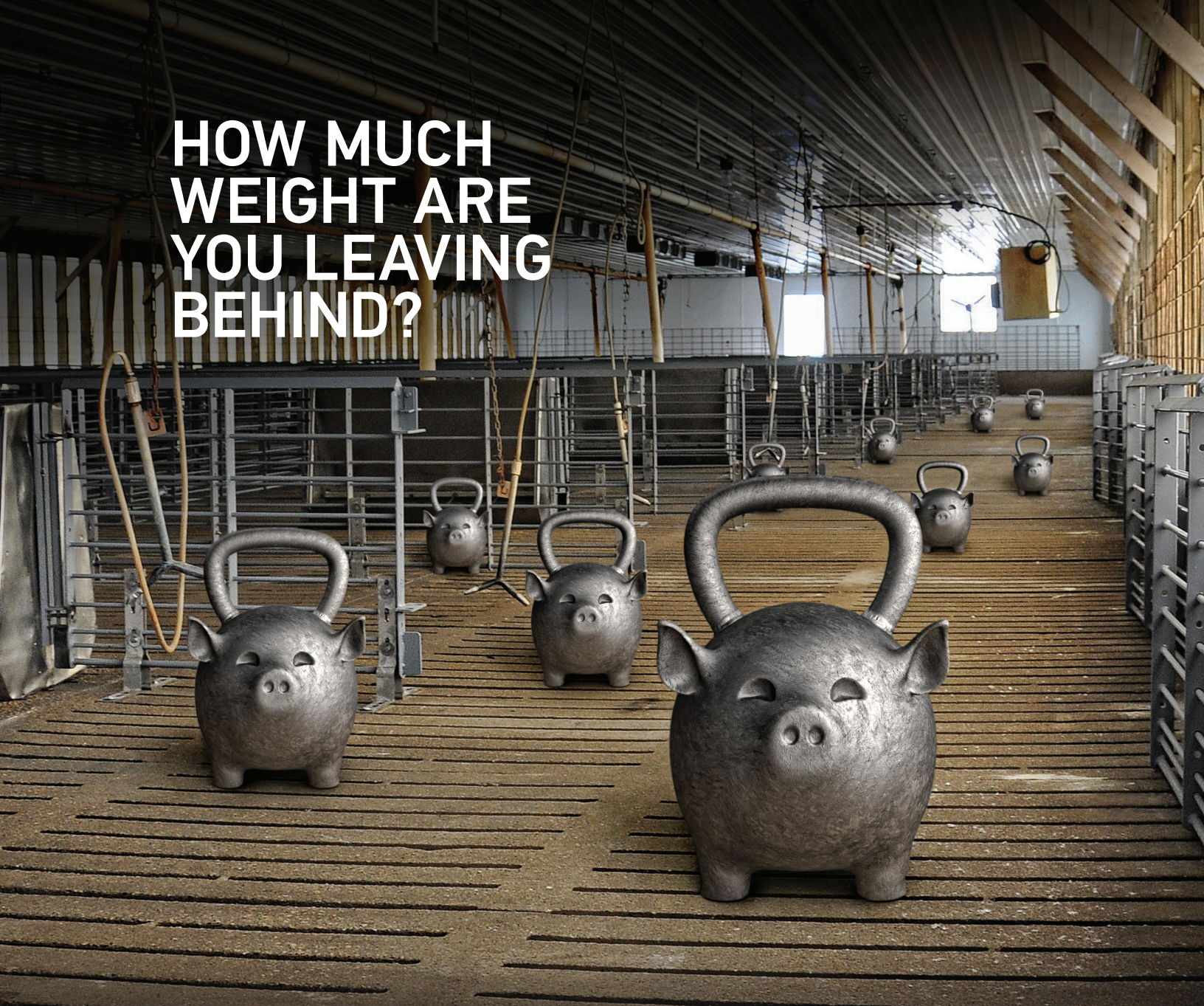
The Iowa State University's Iowa Pork Industry Center (IPIIC) held several Veterinary Feed Directive (VFD) trainings throughout the state to prepare pork producers for the implementation of the revised VFD regulations scheduled for implementation on January 1, 2017. In addition, Dr Chris Rademacher worked with AASV and National Pork Board to

collect a series of VFD questions which he posed to the US Food and Drug Administration. He has posted the agency's official responses to those questions on the IPIIC Web site (<https://www.ipic.iastate.edu/info/VFDfaq.pdf>). The AASV has also included these responses on the association's VFD FAQ web page (<https://www.aasv.org/documents/vfdfaq.php>) as well. Visit

these resources if you have a question regarding the VFD. Chances are someone has already asked a similar question. If you still have questions, you can pose those directly to FDA at [AskCVM@fda.hhs.gov](mailto:AskCVM@fda.hhs.gov) and receive an official response.



# HOW MUCH WEIGHT ARE YOU LEAVING BEHIND?



Reduce market weight variation and turn the barn faster with 3FLEX®. The first and only USDA-licensed trivalent vaccine to offer protection against three of the toughest respiratory diseases in a single syringe.

Only 3FLEX® has the patented adjuvant ImpranFLEX®, proven safe and effective to use with Ingelvac PRRS® MLV.

Get the last 20% of your barn to market faster with the industry's most complete PRDC\* protocol. And see how it benefits your bottom line. Pig after pig after pig. For more details, visit [bi-vetmedica.com/swine](http://bi-vetmedica.com/swine).



\*PRDC stands for Porcine Respiratory Disease Complex.

3FLEX, Ingelvac PRRS and ImpranFLEX are registered trademarks of Boehringer Ingelheim Vetmedica GmbH. ©2016 Boehringer Ingelheim Vetmedica, Inc.



# 48<sup>th</sup> AASV Annual Meeting

February 25 - 28, 2017

Denver, Colorado

## One World, One Health, One Passion for Pigs



**Howard Dunne  
Memorial Lecture**

Dr Jeff Zimmerman

**Alex Hogg  
Memorial Lecture**

Dr Matthew Turner

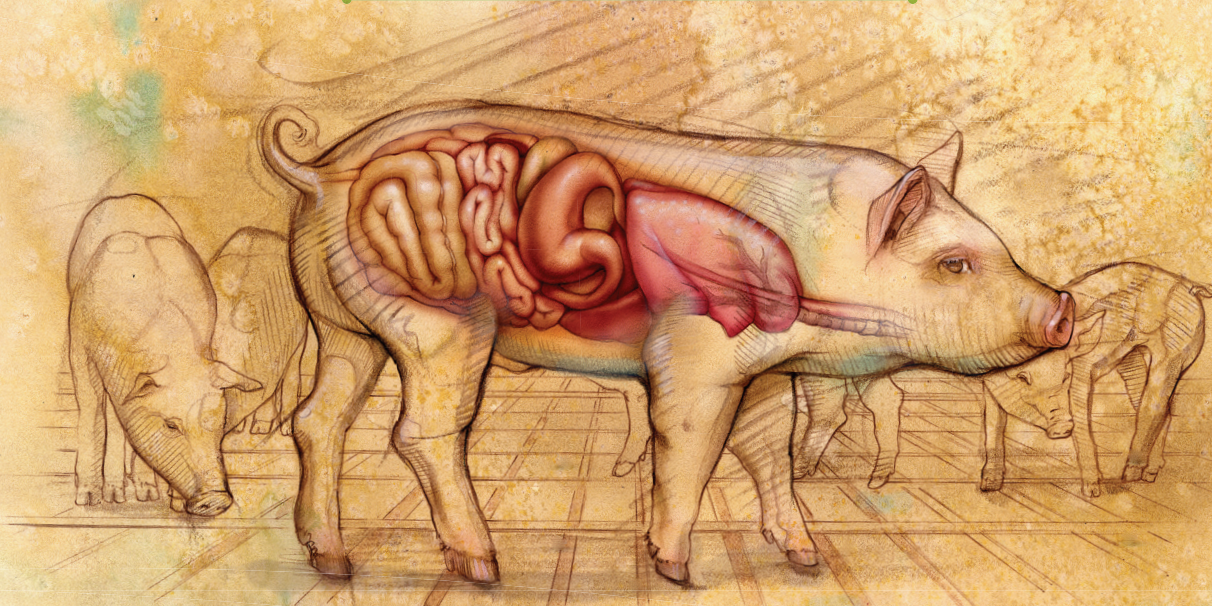
**Register now:  
[www.aasv.org/annmtg](http://www.aasv.org/annmtg)**

Hyatt Regency Denver  
650 15<sup>th</sup> Street  
Denver, CO 80202  
303-436-1234

**For more information: <https://www.aasv.org/annmtg>**



# GOING WHOLE HOG



## **THE ONLY ENROFLOXACIN APPROVED to FIGHT *E. COLI* and for IM ADMINISTRATION**

With approvals for intramuscular injection in swine and control of colibacillosis in groups or pens of weaned pigs where colibacillosis associated with *E.coli* has been diagnosed, Baytril 100 is more versatile than ever. It even offers a dilution schedule for small pigs.

**MORE WAYS BAYER IS HELPING SAVE YOUR BACON**



For use by or on the order of a licensed veterinarian. Extra-label use in food-producing animals is prohibited. Swine intended for human consumption must not be slaughtered within 5 days of receiving a single-injection dose.

# FOUNDATION NEWS

## Give generously in Denver



With the help of AASV members and industry supporters, the AASV Foundation Auction Committee hopes to soar to new heights in fundraising at the 2017 AASV Live and Silent Auctions in Denver.

New this year, the silent auction is going electronic! The auction items are described at [www.aasv.org/foundation](http://www.aasv.org/foundation) and will be on display at the AASV Annual Meeting in Denver, but you can bid early (and often!) from your phone using the new mobile bidding app. Silent Auction bidding will close Monday evening (February 27) during the AASV Awards Reception. As usual, the live auction will be held at the conclusion of the Awards Reception.

Check out the items up for bid at [www.aasv.org/foundation](http://www.aasv.org/foundation), download the bidding app, and support the foundation by participating in the auction – even if you're not going to be at the meeting in Denver.

Since all of the auction items have been donated, the maximum value of each winning bid will support AASV Foundation programs, including swine research, scholarships, swine externship grants, support for members pursuing board certification in the American College of Animal Welfare, travel stipends for veterinary students, tuition grants at the Swine Medicine Education Center, Heritage videos, and more!

Thank you for supporting the foundation with your auction donations and bids!

## Research proposals sought for funding in 2017

As part of its mission to fund research with direct application to the profession, the American Association of Swine Veterinarians Foundation seeks research proposals for funding in 2017. Proposals are due **January 16, 2017**, and may request a maximum of \$30,000 (US\$) per project. A maximum of \$60,000 will be awarded across two or more projects. The announcement of projects selected for funding will take place at the AASV Foundation Luncheon in Denver, Colorado, on Sunday, February 26, 2017 (awardees will be notified in advance).

Proposed research should fit one of the five action areas stated in the AASV Foundation Mission Statement (see sidebar).

The instructions for submitting proposals are available on the AASV Foundation Web site at <https://www.aasv.org/foundation/2017/research.php>.

Proposals may be submitted by mail or e-mail (preferred).

A panel of AASV members will evaluate and select proposals for funding, on the basis of the following scoring system:

- \* Potential benefit to swine veterinarians/swine industry (40 points)
- \* Probability of success within timeline (35 points)
- \* Scientific/investigative quality (15 points)
- \* Budget justification (5 points)
- \* Originality (5 points)

For more information, or to submit a proposal:

AASV Foundation, 830 26<sup>th</sup> Street, Perry, IA 50220-2328; Tel: 515-465-5255; Fax: 515-465-3832; E-mail: [aasv@aasv.org](mailto:aasv@aasv.org).

### AASV Foundation Mission Statement

The mission of the American Association of Swine Veterinarians Foundation is to empower swine veterinarians to achieve a higher level of personal and professional effectiveness by

- Enhancing the image of the swine veterinary profession,
- Supporting the development and scholarship of students and veterinarians interested in the swine industry,
- Addressing long-range issues of the profession,
- Supporting faculty and promoting excellence in the teaching of swine health and production, and
- Funding research with direct application to the profession.

# Swine veterinarians invited to apply for Hogg Scholarship

The American Association of Swine Veterinarians Foundation is pleased to offer the Hogg Scholarship, established to honor the memory of longtime AASV member and swine industry leader Dr Alex Hogg. Applications for the \$10,000 scholarship will be accepted until February 1, 2017, and the scholarship recipient will be announced on Sunday, February 26, during the Foundation Luncheon at the AASV 2017 Annual Meeting in Denver.

The intent of the scholarship is to assist a swine veterinarian in his or her efforts to return to school for graduate education (resulting in a master's degree or higher) in an academic field of study related to swine health and production.

Dr Alex Hogg's career serves as the ideal model for successful applicants. After 20 years in mixed-animal practice, Dr Hogg pursued a master's degree in veterinary pathology. He subsequently became Nebraska swine extension veterinarian and professor at the University of Nebraska. Upon "retirement," Dr Hogg capped off his career with his work for MVP Laboratories. Always an enthusiastic learner, at age 75 he graduated from the Executive Veterinary Program offered at the University of Illinois.

The scholarship application requirements are outlined below, and on the AASV Web site at <http://www.aasv.org/foundation/hoggscholarship.htm>.

## Hogg Scholarship application requirements

An applicant for the Hogg Scholarship shall have

1. Five or more years of experience as a swine veterinarian, either in a private practice or in an integrated production setting; and
2. Five or more years of continuous membership in the American Association of Swine Veterinarians.

Applicants are required to submit the following for consideration as a Hogg Scholar:

1. Current curriculum vitae,
2. Letter of intent detailing his or her plans for graduate education and future plans for participation and employment within the swine industry, and
3. Two letters of reference from AASV members attesting to the applicant's qualifications to be a Hogg Scholar.

Applications and requests for information may be addressed to AASV Foundation, 830 26<sup>th</sup> Street, Perry, IA 50220-2328; Tel: 515-465-5255; E-mail: [aasv@aasv.org](mailto:aasv@aasv.org).



Bayer ad continued from page 42

## Injectable **Baytril® 100** (enrofloxacin)

**100 mg/mL Antimicrobial Injectable Solution**  
For Subcutaneous use In Beef Cattle, Non-Lactating Dairy Cattle  
For Intramuscular Or Subcutaneous Use In Swine  
Not For Use In Female Dairy Cattle 20 Months Of Age Or Older  
Or In Calves To Be Processed For Veal

**BRIEF SUMMARY:**  
Before using Baytril® 100, please consult the product insert, a summary of which follows:

**CAUTION:**  
Federal (U.S.A.) law restricts this drug to use by or on the order of a licensed veterinarian.  
Federal (U.S.A.) law prohibits the extra-label use of this drug in food-producing animals.

To assure responsible antimicrobial drug use, enrofloxacin should only be used as a second-line drug for colibacillosis in swine following consideration of other therapeutic options.

**INDICATIONS:**  
**Cattle - Single-Dose Therapy:** Baytril® 100 is indicated for the treatment of bovine respiratory disease (BRD) associated with *Mannheimia haemolytica*, *Pasteurella multocida*, *Histophilus somni* and *Mycoplasma bovis* in beef and non-lactating dairy cattle; and for the control of BRD in beef and non-lactating dairy cattle at high risk of developing BRD associated with *M. haemolytica*, *P. multocida*, *H. somni* and *M. bovis*.

**Cattle - Multiple-Day Therapy:** Baytril® 100 is indicated for the treatment of bovine respiratory disease (BRD) associated with *Mannheimia haemolytica*, *Pasteurella multocida* and *Histophilus somni* in beef and non-lactating dairy cattle.

**Swine:** Baytril® 100 is indicated for the treatment and control of swine respiratory disease (SRD) associated with *Actinobacillus pleuropneumoniae*, *Pasteurella multocida*, *Haemophilus parasuis*, *Streptococcus suis*, *Bordetella bronchiseptica* and *Mycoplasma hyopneumoniae*. Baytril® 100 is indicated for the control of colibacillosis in groups or pens of weaned pigs where colibacillosis associated with *Escherichia coli* has been diagnosed.

Use within 30 days of first puncture and puncture a maximum of 30 times with a needle or 4 times with a dosage delivery device. Any product remaining beyond these parameters should be discarded.

### RESIDUE WARNINGS:

**Cattle:** Animals intended for human consumption must not be slaughtered within 28 days from the last treatment. This product is not approved for female dairy cattle 20 months of age or older, including dry dairy cows. Use in these cattle may cause drug residues in milk and/or in calves born to these cows. A withdrawal period has not been established for this product in pre-ruminating calves. Do not use in calves to be processed for veal.

**Swine:** Animals intended for human consumption must not be slaughtered within 5 days of receiving a single-injection dose.

### HUMAN WARNINGS:

**For use in animals only. Keep out of the reach of children.** Avoid contact with eyes. In case of contact, immediately flush eyes with copious amounts of water for 15 minutes. In case of dermal contact, wash skin with soap and water. Consult a physician if irritation persists following ocular or dermal exposures. Individuals with a history of hypersensitivity to quinolones should avoid this product. In humans, there is a risk of user photosensitization within a few hours after excessive exposure to quinolones. If excessive accidental exposure occurs, avoid direct sunlight. For customer service or to obtain product information, including a Safety Data Sheet, call 1-800-633-3796. For medical emergencies or to report adverse reactions, call 1-800-422-9874.

### PRECAUTIONS:

The effects of enrofloxacin on cattle or swine reproductive performance, pregnancy and lactation have not been adequately determined.

The long-term effects on articular joint cartilage have not been determined in pigs above market weight.

Subcutaneous injection in cattle and swine, or intramuscular injection in swine, can cause a transient local tissue reaction that may result in trim loss of edible tissue at slaughter.

Baytril® 100 contains different excipients than other Baytril® products. The safety and efficacy of this formulation in species other than cattle and swine have not been determined.

Quinolone-class drugs should be used with caution in animals with known or suspected Central Nervous System (CNS) disorders. In such animals, quinolones have, in rare instances, been associated with CNS stimulation which may lead to convulsive seizures. Quinolone-class drugs have been shown to produce erosions of cartilage of weight-bearing joints and other signs of arthropathy in immature animals of various species. See Animal Safety section for additional information.

### ADVERSE REACTIONS:

No adverse reactions were observed during clinical trials.

### ANIMAL SAFETY:

In feeder calves, clinical signs including depression, incoordination, muscle fasciculation and inappetence have been observed at higher than approved label dosages. In swine subcutaneous safety studies, incidental lameness of short duration and musculoskeletal stiffness have been observed at higher than approved label dosages.

In swine intramuscular safety studies, transient decreases in feed and water consumption were observed after each treatment. Mild, transient, post-treatment injection site swellings were observed in pigs receiving the 37.5 mg/kg BW dose. Injection site inflammation was found on post-mortem examination in all enrofloxacin-treated groups.

V-04/2016  
©2015 Bayer HealthCare LLC

Baytril® 100  
Bayer, the Bayer Cross and Baytril are registered trademarks of Bayer.  
NADA 141-068, Approved by FDA  
Bayer HealthCare LLC, Animal Health Division  
Shawnee Mission, Kansas 66201 U.S.A.  
GHG112816

**Bayer**

## Change – the one constant

**I**t's a time of change. I thought this might be a good opportunity to review some of the critical aspects of the new world order involving feed-grade antibiotics. In the process of recovering from your New Year's celebration and focusing on the presidential inauguration, it may have slipped your mind that the revised regulations governing the Veterinary Feed Directive (VFD)<sup>1</sup> have now taken full effect. The manufacturers agreed to remove the growth promotion claims from their product labels and transition all medically important feed grade antibiotics to VFD status by December 31, 2016.

These regulatory changes, in conjunction with the implementation of Guidance for Industry (GFI) #209 and #213,<sup>2</sup> are designed to eliminate the growth promotion uses of medically important antimicrobials and enhance veterinary oversight of antimicrobial use in livestock. This means that as of January 1, the use of any feed-grade antibiotic with a VFD label is subject to the new rules. This includes tilmicosin, florfenicol, and avilamycin, which were all approved as VFD drugs, as well as most other products traditionally marketed over-the-counter (OTC).

A list of "medically important" antimicrobials can be found in FDA's Guidance #152 Appendix A.<sup>3</sup> Basically, all swine antibiotics were affected except bacitracin, carbadox, bambarmycin, ionophores, and tiamulin. These antibiotics will remain available for growth promotion and (or) OTC distribution.

### Veterinary responsibilities

In order to comply with the new VFD rules, the veterinarian must

- be licensed and operating in the course of normal practice in compliance with all state and federal regulations;
- write VFD orders in the context of a veterinary-client-patient relationship (VCPR) as discussed below;
- only issue a VFD that is in compliance with approved use;
- prepare a written (nonverbal) VFD including the veterinarian's signature;
- ensure the VFD includes all required information (refer to the list in the AASV VFD brochure<sup>4</sup>). While there is no FDA-approved standardized VFD form, the agency did provide a sample form that veterinarians can use. In addition, many of the drug manufacturers have also produced forms for their specific VFD drugs. Access to all these sample forms is available on the AASV VFD Web page.<sup>5</sup>
- include certain drug-specific information for each VFD drug when authorizing drug combinations that include more than one VFD drug;
- when issuing a VFD combining VFD and OTC drugs, include on the VFD order an affirmation of intent either to restrict authorized use only to the VFD drug cited on the VFD form or to allow the use of the cited VFD drug in an approved combination with one or more OTC drug(s);
- provide the distributor and client with a copy of the VFD order either in hard copy or electronic form or by fax;
- retain the original VFD for 2 years (the client and distributor must likewise retain their copies for 2 years); and
- provide the VFD orders for inspection and copying by FDA upon request.

In addition, it should be emphasized that extra-label use of feed-grade antimicrobials remains **ILLEGAL** for both veterinarians and producers.

---

*"...it may have slipped your mind that the revised regulations governing the Veterinary Feed Directive (VFD) have now taken full effect."*

---

### Veterinary-client-patient relationship

A valid VCPR must exist between the veterinarian, the client, and the animals to be treated in order to issue a VFD. However, there are numerous versions of the VCPR requirements, including versions associated with federal regulations governing extra-label drug use, the American Veterinary Medical Association's model practice act, and state veterinary practice acts. For the purposes of issuing a VFD, FDA defaults to the VCPR requirements defined in the state veterinary practice act, provided those requirements meet the following minimum standards:

1. The veterinarian has engaged with the client to assume responsibility for making clinical judgments about patient health,
2. The veterinarian has sufficient knowledge of the patient by virtue of patient examination and (or) visits to the facility where the patient is managed, and
3. The veterinarian is available to provide for any necessary follow-up evaluation or care.

If the state practice act either does not include a VCPR requirement or does not meet those minimum standards, the VCPR requirement to issue a VFD defaults to the VCPR as defined in association with the Animal Medicinal Drug Use Clarification Act, 21 CFR §530.3(i).<sup>6</sup> The FDA has compiled a list of states that require a VCPR that includes the key elements of the federally defined VCPR in order for a veterinarian to issue a VFD. This list available on the FDA Web site.<sup>7</sup>



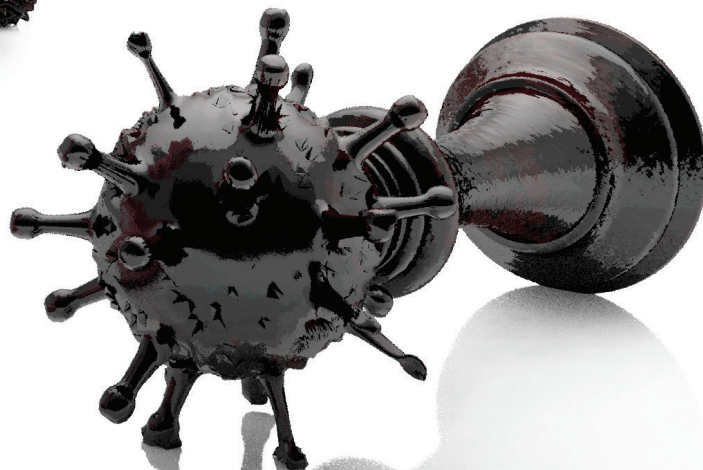
*Advocacy in action continued on page 47*



## Outsmart outbreaks.

Flu strains are constantly evolving. So is FluSure XP®. It's the only commercial swine vaccine that helps provide cross-protection against the most prevalent influenza strains impacting hog farms today,<sup>1,3</sup> backed by the ongoing commitment of Zoetis to actively monitor and combat new strains.

**Keep swine flu in check.**  
Visit [FluSureXP.com](http://FluSureXP.com)



BE SURE WITH **FluSure XP**®

**H1N1** | **H1N2** | **H3N2** | **H3N2**  
GAMMA | DELTA-1 | CLUSTER IV-A | CLUSTER IV-B

**zoetis**

**References:** 1. FluSure XP [package]. Kalamazoo, MI: Zoetis LLC; 2016. 2. Sandbulte MR, Spickler AR, Zaabel PK, Roth JA. Optimal use of vaccines for control of influenza A virus in swine. *Vaccines*. 2015;3:22-73. 3. Veterinary Services, Animal and Plant Health Inspection Service, United States Department of Agriculture. Influenza A virus in swine surveillance: fiscal year 2015 quarterly report. Published February 2016. [https://www.aphis.usda.gov/animal\\_health/animal\\_dis\\_spec/swine/downloads/fy2015quarter4swinereport.pdf](https://www.aphis.usda.gov/animal_health/animal_dis_spec/swine/downloads/fy2015quarter4swinereport.pdf). Accessed October 12, 2016.

All trademarks are the property of Zoetis Services LLC or a related company or a licensor unless otherwise noted.  
© 2016 Zoetis Services LLC. All rights reserved. FXP-00010

## Additional changes of interest

1. The veterinarian must assign an expiration date to the VFD. This date refers to the length of time during which the VFD is valid and the producer can feed the VFD feed, not the date on which the drug expires. The expiration date must comply with the VFD expiration date indicated on the VFD drug label if the product specifies an expiration date (the veterinarian cannot deviate from this date). If the product label does not indicate a specific date, the veterinarian must assign a date not to exceed 6 months from the date of issue.
2. There has been much discussion regarding refills. The veterinarian must specify the number of refills, if refills are allowed according to the VFD drug label. Currently, there are no approved medications for which refills are allowed on the label. Thus, refills are illegal unless a future product approval allows refills.
3. The veterinarian issuing the VFD must comply with the veterinary practice act regulations in effect in the state in which the animals that are to receive the VFD feed reside.
4. In contrast to the current VFD requirements, the new rule requires that the veterinarian estimate the number of animals that will receive the VFD feed rather than the volume of feed that needs to be produced.
5. In another change, the VFD may now be transmitted to the feed manufacturer-distributor and to the client electronically (ie, by fax or through a compliant third-party electronic database, but not by telephone) instead of only by hard copy. The veterinarian retains the original copy in whatever format it was generated. The distributor and client copies may be kept either as electronic copies or hard copy. All copies of the VFD must be retained for a minimum of 2 years by the veterinarian, client, and distributor.
6. If any drug in an approved combination drug product is a VFD drug, the use of that combination must comply with the VFD rule.
7. The veterinarian may write a VFD that covers animals in multiple locations (animal production facilities) to be fed

the VFD feed by the expiration date on the VFD, provided he or she can do so in compliance with professional licensing and practice standards and provided the VFD feed is supplied to such multiple locations by a single feed manufacturer (distributor).

8. Electronic VFD orders issued by veterinarians must be compliant with 21 CFR part 11, and electronic VFD orders received and electronically stored by distributors and clients must also be compliant with 21 CFR part 11.<sup>8</sup> Part 11 of 21 CFR does not apply to paper records that are, or have been, transmitted by electronic means (such as facsimile, e-mail attachments, etc).
9. There are additional requirements to meet if a veterinarian also distributes VFD feed.

## Water medications

It should also be noted that as of January 1, all medically important water medications transitioned from OTC to prescription status. What this means is that access to these products will now have to comply with the pharmacy laws in each individual state, just like any other prescription product. You will need to refer to the individual state veterinary practice acts and state pharmacy laws to determine how to legally prescribe and dispense water medications.

In summary, as of January 1, 2017 all VFD-labeled products became subject to the new VFD rules and all medically important water medications transitioned to prescription status. Additionally, all growth-promotion claims were removed from all medically important antibiotics, making it illegal to utilize those products for the purpose of growth promotion. I have attempted to highlight the key responsibilities of the veterinarian, but I urge you to familiarize yourselves with the regulation. The FDA has compiled a fact sheet describing the background and reasons for the changes to the VFD.<sup>9</sup> The agency has also published an additional draft guidance document, GFI #120, which answers many of the most frequently asked questions.<sup>10</sup> All these documents can be found online, as referenced below. In addition, AASV has a wealth of information available on the AASV VFD Web page including a series of frequently asked questions with the official responses from FDA.<sup>5</sup>

## References

1. Final Rule: Veterinary Feed Directive. Available at <https://www.federalregister.gov/articles/2015/06/03/2015-13393/veterinary-feed-directive>. Accessed 11 November 2016.
2. Guidance for Industry #213. Contains Nonbinding Recommendations. Guidance for Industry. New Animal Drugs and New Animal Drug Combination Products Administered in or on Medicated Feed or Drinking Water of Food Producing Animals: Recommendations for Drug Sponsors for Voluntarily Aligning Product Use Conditions with GFI #209. Food and Drug Administration. Available at <http://www.fda.gov/downloads/AnimalVeterinary/GuidanceComplianceEnforcement/GuidanceforIndustry/UCM299624.pdf>. Accessed 1 December 2016.
3. FDA Guidance for Industry #152. Available at <http://www.fda.gov/downloads/AnimalVeterinary/GuidanceComplianceEnforcement/GuidanceforIndustry/ucm052519.pdf>. Accessed 11 November 2016.
4. Changes in the Veterinary Feed Directive (VFD): What the swine veterinarian needs to know. <https://www.aasv.org/documents/VFD.pdf>. Accessed 11 November, 2016.
5. AASV Veterinary Feed Directive. Available at <https://www.aasv.org/aasv%20website/Resources/Antimicrobial%20Use/VFD.php>. Accessed 11 November 2016.
6. Animal Medicinal Drug Use Clarification Act of 1994. Available at <http://www.ecfr.gov/cgi-bin/text-idx?SID=054808d2b1de27878e02fb175b7c9ff9&node=21:b.ch.l.j.l&rgn=div5>. Accessed 11 November 2016.
7. FDA listing of state VCPR requirements. Available at <http://www.fda.gov/AnimalVeterinary/DevelopmentApprovalProcess/ucm460406.htm>. Accessed 11 November 2016.
8. 21 CFR Part 11 compliance. Available at <http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfcfr/CFRSearch.cfm?CFRPart=11>. Accessed 11 November 2016.
9. VFD Final Rule Fact Sheet. Available at <http://www.fda.gov/AnimalVeterinary/DevelopmentApprovalProcess/ucm449019.htm>. Accessed 11 November 2016.
10. Guidance #120 VFD Frequently Asked Questions. Available at <http://www.fda.gov/downloads/AnimalVeterinary/GuidanceComplianceEnforcement/GuidanceforIndustry/UCM052660.pdf>. Accessed 11 November 2016.

Harry Snelson, DVM  
Director of Communications



# VICE-PRESIDENTIAL CANDIDATE

## Brian Schantz

It is an honor to be nominated to run for the position of vice president of the AASV. For the past 27 years I have belted up to the AASV buffet and have consumed a tremendous amount. By potentially serving in this capacity, I could give back a small amount of time and effort in return for the vast amount that I have consumed. The AASV has served as the fuel for my career. I have used AASV not only for knowledge gain, but for networking, support, new product discovery, sometimes chastisement, friendships, etc. Without AASV, it would be very difficult to stay current and connected.

I grew up on a small diversified farm in northeast Nebraska. I was the oldest of four boys and my father made it clear when I was young that the opportunity for me to stay home and farm was not good. So, when I was 9 years old, I declared that I was going to be a veterinarian. I really had very little idea what that would entail, but somehow, 15 years later, I graduated from Iowa State with my DVM. I started in 1988 and was fortunate to experience a mixed-animal, “James Harriot” type practice for nearly 9 years. But, as we all know, nothing stays the same. Our clientele morphed from small farrow-to-finish operations to cooperatively owned sow reproductive centers with two- and three-site production. Along with veterinary medicine, we began to be asked to deal with human-resource issues, book-keeping, record-keeping, building design, contractual agreements, etc. In 1997, I decided to partner with an accountant and opened a swine management company and veterinary practice. We have endeavored to do this ever since.

One of the biggest dichotomies in life and practice is that change is constant. I remember talking with older veterinarians about how they thought that, as soon as hog chol-

era was eradicated, swine veterinary practice would pretty much be done. Similarly, many worried that as soon as pseudorabies virus (PRV) was eradicated, swine medicine would flounder. When I graduated from veterinary school in 1988, swine medicine was primarily bacterial diseases and PRV. There was, however, an emerging problem called “mystery swine disease” that was starting to make some noise. It turns out that initial noise was the tip of a massive emerging iceberg. After nearly 30 years, porcine reproductive and respiratory syndrome (PRRS) still has a massive impact. While we have been dealing with PRRS, there has been a revolving door of new or re-emerged diseases popping up constantly. The diseases of swine will continue to change and will continue to provide our profession with a challenge and something to do.

When I graduated, biosecurity was a change in coveralls and a bucket of disinfectant with a boot brush. Now we have truck washes with baking bays, filtered barns, and strict biosecurity standard operating procedures. A large sow unit was anything over 500 sows. Now, some question if anything under 3000 is feasible long-term. Pig farm labor was performed by land-based farmers and their families. Now, the labor force is culturally diverse, male or female with or without any history of livestock background. Producers were free to raise pigs in basically any way they deemed right or convenient. Today we have “PQA,” “TQA,” “CSIA,” and “VFD” with more acronyms to come. The swine industry itself will continue to change and also will continue to provide our profession with a challenge and something to do.

I am reminded of an old joke which I’ve modified some. How many swine veterinarians does it take to change a light bulb? The



answer is five. One to change the bulb, two to talk about how good the old bulb was, and two to make an acronym for the new light bulb. As swine veterinarians, we can sit back and talk about the good old days and lament the current climate, or we can roll up our sleeves and attack the future. What will the future bring? No one knows for sure, but with an organization like AASV we can come together and prepare. We are a massively diverse organization with unending ideas and resources. Yet we are small enough to be nimble, intimate, and responsive. As professionals that are looked to for advice, encouragement, and input, we need to prepare ourselves to be competent in all of these aspects. The AASV can and will be the backbone for that preparation.

If elected, I will be honored to be part of the team that helps AASV adapt and move forward with the changes that we currently face and the ones yet to come.





# VICE-PRESIDENTIAL CANDIDATE

## Nathan Winkelman

Thank you! Being asked to serve as an AASV officer is an honor and presents an opportunity for me to give back to the organization that has given so much to me. I'm proud to say that I have been to every AASV-AASP meeting since I was a vet student in 1982. Obviously the knowledge gained, contacts made, and the camaraderie with colleagues is very important to me. Part of the AASV mission statement is to "create opportunities that inspire personal and professional growth and interaction." This AASV mission has been more than fulfilled during my membership.

**Past.** The farmer work ethic was a way of life growing up on a diversified crop and livestock farm near St James, Minnesota. My father and mother kept their six kids busy with our farrow-to-finish swine operation, beef cow-calf herd, feedlots, laying hens, and fieldwork. Inspired by my veterinarian uncle, FFA instructor, and our local vets, I had always wanted to be a veterinarian since high school.

After receiving a BS in Animal Science, my swine focus intensified while managing a farm where Dr Jim Dick visited weekly. He introduced to me Dr Al Leman, who hired me to work with Drs Brad Thacker and Han Soo Joo while in vet school. Externships with Dr Roy Schultz, Drs Connie Schmidt, and Wayne Freese solidified my decision to become a swine practitioner. All of these mentors are great past and present leaders in the AASV.

With a DVM degree in 1984, I was likely the first vet student to go into a "swine exclusive practice" right out of school to work for Drs Rod Johnson and Tony Scheiber. There were very few swine-only practices, and the swine industry as we know it today was in its infancy. Today's 1289 AASV members consist of 47% practitioners, and 26% are exclusively swine vets.

**Present.** Currently, I'm a partner with Dr Adam Mueller in Swine Services Unlimited, Inc, a swine research and consulting practice in Rice, Minnesota. Our business focus is consulting with loyal, progressive pork-producer clients, some of whom we've seen each month for over 35 years! Swine Services Unlimited, Inc, is also a contract research organization conducting swine disease trials for many of those corporate sponsor companies who support the AASV. This research has allowed me to author or co-author many scientific papers and open doors for international consulting opportunities to gain a global industry perspective.

Deb Bryant, my wife, is also a veterinarian, and we have two wonderful grown "children." We have a hobby-farm menagerie with horses, goats, chickens, dogs, and cats (no pigs, of course). My many hobbies include scientific and non-fictional reading, bird hunting, bird watching (different from those I hunt), hiking and canoeing in northern Minnesota, and all things sports and nature.

Professional memberships include the AVMA and MVMA since graduation. I've been on the AASV Board of Directors, and I am currently on the AASV Foundation Board and chair the Foundations Research Project Selection Committee. We have been awarding \$60,000 annually to worthy members' research projects. These monies come from membership donations from the Leman Fellow, Heritage Fellow, and Legacy Fellow. Thank you all for your past and future foundation donations. The AASV committees provide specific direction to the board of directors, and I am currently active on the Operation Main Street (OMS) Committee. This is another excellent way to advocate our profession and industry to others – please consider OMS.



**Future.** Some of the challenges the AASV is and will be facing are global and domestic pathogen biosecurity, antibiotic usage and the ONE HEALTH Initiative, animal welfare issues, vet student debt and starting salaries, and industry transparency and professionalism through science to maintain consumer confidence. These challenges are really just opportunities for the AASV members, staff, and leadership for continued progress. As always, we will continue to be industry and global leaders in science-based advancements in working with our clients to provide safe, nutritious, and affordable pork for the world.



## Guidelines for authors submitting manuscripts

Prepare the manuscript in Word using Times New Roman 12-point font, double-spaced throughout. Submit manuscripts to the Publications Manager.

Please include:

- An electronic copy of your manuscript, with pages and lines numbered continuously;
- Files of all figures and tables;
- For all authors, names (first, middle initial, last), affiliations, and academic degrees beyond bachelor's level; and
- For the corresponding author, complete mailing address, telephone number, fax number, and e-mail address (please indicate whether you wish the e-mail address published).

Unless given alternate instructions, we will correspond with the first author, who will also receive reader inquiries and requests for reprints.

We will have your summary professionally translated into French and Spanish.

### Editorial office

Karen Richardson, Publications Manager,  
*Journal of Swine Health and Production*;  
Tel: 519-856-2089; Fax: 519-763-3117;  
E-mail: [pub\\_mgr@aaasv.org](mailto:pub_mgr@aaasv.org).

### Animal care

For experiments performed in research facilities or on commercial farms, include a statement at the beginning of the materials and methods indicating that the studies were reviewed and approved by the institutional animal care and use committee (or equivalent). For case reports and studies performed under field conditions in which animals are not manipulated beyond what would be required for diagnostic purposes, it must be clear that housing was adequate and that the animals were humanely cared for.

### Permissions

If you are using copyrighted material, you must advise the editors of this when you submit your manuscript. You are responsible for securing permission to use copyrighted art or text, including the payment of fees.

### Copyright transfer

When a manuscript is submitted to the *Journal of Swine Health and Production*, a pre-review copyright agreement and financial disclosure statement must be signed by all authors. It is the responsibility of the corresponding author to secure these signatures. This form is available from the Publications Manager. Submit signed copies to Karen Richardson. When your manuscript is accepted for publication, you will be required to transfer copyright to the American Association of Swine Veterinarians, with the exceptions of United States government employees whose work is in the public domain, and portions of manuscripts used by permission of another copyright holder.

### Prior publication

We do not republish materials previously published in refereed journals. Sections of theses and extension publications that may be of particular value to our readership will be considered. Prior publication of an abstract only (for example, in a proceedings book) is generally acceptable.

### Types of articles

The *Journal of Swine Health and Production* publishes the following types of peer-reviewed manuscripts:

- Original research
- Brief communication
- Case report
- Case study
- Literature review
- Production tool
- Peer-reviewed commentary
- Peer-reviewed diagnostic notes
- Peer-reviewed practice tip

### Reference format

Authors are responsible for the accuracy of their references. References must be cited in the text using consecutive superscript numbers and listed at the end of the text in numerical order. Non-refereed references are marked with an asterisk to the left of the reference number. Only personal communications may remain in the text in parentheses. Refer to recent issues of the *Journal of Swine Health and Production* for examples of formatting for specific types of references.

### Figures and tables

- Tables must be prepared using the table function in Word.
- Place the figure legends and the set of tables after the reference list in the manuscript.
- Do not paste figures into the word-processing document containing the text of the manuscript. Submit them separately, eg, submit figures created in Excel as Excel files, and submit figures created in other programs as .eps files (ie, save as .eps files from within the program that created the figures).
- Make reference in the text to all figures and tables, citing them in consecutive order.
- Provide us with numerical data for all figures, including SD or SE for means.
- Supply brief but complete titles for tables and legends for figures. Explain in footnotes abbreviations used in tables, using symbols to identify footnotes.
- For *P* values reported in a table or figure, provide the name of the statistical method used (eg, *t* test, ANOVA), not the name of the software.
- Submit photographs as individual high-resolution .jpeg images or in .tif files.

### Measurements

The *Journal of Swine Health and Production* adheres, with a few exceptions, to the style of the American Medical Association.<sup>1</sup> A conversion chart is included at the end of the author guidelines document on the Web site at <http://www.aaasv.org/shap/guidelines.pdf>. Please see the Web version of author guidelines for full details on journal requirements for submitted manuscripts.

### Reference

1. Iverson C, Christiansen S, Flanagan A, JAMA and Archives Journals Staff, eds. *AMA Manual of Style: A Guide for Authors and Editors*. 10<sup>th</sup> ed. New York, New York: Oxford University Press. 2007.



# UPCOMING MEETINGS

## Banff Pork Seminar

January 10-12, 2017 (Tue-Thu)  
Banff, Alberta, Canada

For more information:  
Tel: 780-492-3651  
E-mail: [pork@ualberta.ca](mailto:pork@ualberta.ca)  
Web: <http://www.banffpork.ca>

## 2017 Pig-Group Ski Seminar

February 8-10, 2017 (Wed-Fri)  
Copper Mountain, Colorado

For more information:  
Lori Yeske  
Pig Group  
39109 375<sup>th</sup> Ave  
St Peter, MN 56082  
Tel: 507-381-1647  
E-mail: [pyeske@swinevetcenter.com](mailto:pyeske@swinevetcenter.com)

## American Association of Swine Veterinarians 48<sup>th</sup> Annual Meeting

February 25-28, 2017 (Sat-Tue)  
Hyatt Regency Denver  
Denver, Colorado

For more information:  
American Association of Swine Veterinarians  
830 26<sup>th</sup> Street  
Perry, IA 50220-2328  
Tel: 515-465-5255; Fax: 515-465-3832  
E-mail: [aasv@aasv.org](mailto:aasv@aasv.org)

## World Pork Expo

June 7-9, 2017 (Wed-Fri)  
Iowa State Fairgrounds  
Des Moines, Iowa

Hosted by the National Pork Producers Council

For more information:  
National Pork Producers Council  
10676 Justin Drive  
Urbandale, IA 50322  
Web: <http://www.worldpork.org>

## 25<sup>th</sup> International Pig Veterinary Society Congress

June 11-14, 2018 (Mon-Thu)  
Chongqing, China

For more information:  
Web: <http://www.ipvs2018.net/>



For additional information on upcoming meetings: <https://www.aasv.org/meetings/>

## AASV Industry Support Council

*Journal of Swine Health and Production* is made possible by the generous support of the following Industry Support Council members:



**Boehringer  
Ingelheim**



**MERCK**  
Animal Health



**PHARMACOSMOS**  
Committed to Quality



**Tonistry**



## Photo Corner

Curious University of Missouri pigs

*Photo courtesy of Tina Smith*

AASV Resources online at <https://www.aasv.org>