Use of novel technologies to optimize pig performance, welfare and carcass value

Brian Sullivan, Canadian Centre for Swine Improvement (CCSI)

Project Status: Completed in 2018

Water dispensers. Source: CDPQ

Certain economically important traits, such as growth, feed efficiency, welfare and carcass quality, are difficult or expensive to measure in pig farms and slaughter plants. Recent technological developments provided new opportunities to collect information on live pigs and carcasses.

This project looked at validating some of the new technologies available to provide objective indicators of performance, welfare and carcass value.

Pilot studies on both live pigs and carcasses, along with a commercial trial and demonstration activity, were carried out as described below.

Fifteen researchers from ten different institutions worked in collaboration on this project.

Automated recording of individual water usage

Frédéric Fortin and Patrick Gagnon,
Centre de développement du porc du Québec (CDPQ)

Results of this study showed that recording systems for water usage per pen could be an interesting option for commercial farms. Water intake (per pen) can be used to predict growth and feed conversion. It can also be an early indicator of health issues, as intake drops up to three days prior to disease symptoms.

Why was this work done?

Collecting individual water intake data can help to detect potential health or welfare issues in addition to providing behaviour measurements. Monitoring water usage may also be a valuable approach towards more sustainable pig production and resistance to heat or drought.

What was done and what was the outcome?

New individual water intake recording systems (smart drinkers) were installed at the CDPQ Deschambault swine testing station in Québec. These smart drinkers allowed water intake patterns to be studied on a barn, pen and individual basis and links with other traits such as feed intake, growth performance, carcass quality and health status can be explored.

Water intake from about 700 pigs was analyzed and a good correlation between water and feed intake was found. However, there was a large seasonal effect, with pigs eating less and drinking more in summer months. While water intake can be used to predict growth and feed conversion at the pen level, individual pig usage is less accurate, largely due to a large variation in wastage.

Water intake can also be used at the pen or barn level as an indicator of health issues. Warning levels can be set up and were shown to predict health issues up to three days prior to animals showing symptoms.

Recording systems for water usage per pen could be an interesting option for commercial use as they do not require electronic identification of individual pigs and can be done with a simpler version of the smart drinker.

Automated recording of pig body temperature using infrared technology in the eye area

Frédéric Fortin and Patrick Gagnon,
Centre de développement du porc du Québec (CDPQ)

Researchers found that measuring the temperature of the pigs' eye area using infrared thermography was a practical method to take pig temperature, a promising indicator of health, stress and performance.

Why was this work done?

The value of infrared thermography (IRT) in pig production and research resides in its ability to provide temperature information on animals non-invasively. However, there is a need to define standard measurement sites in order to optimize the use of the IRT data as a predictor of health, stress and performance. Thus, the principal objective of this study was to estimate pig temperature in barn conditions using infrared thermography on a specific area near the eye.

What was done and what was the outcome?

This study was carried out in two phases. For Phase 1, manual and automated IRT pictures were taken to measure temperatures of pigs' eyes and ears. Pictures taken automatically from above the water bowl showed that eye temperature was easier to obtain.

For Phase 2, promising results were obtained with a new water bowl designed specifically to hold the IRT cameras securely and at different heights. However, some practical issues would still need to be addressed before implementing this system in commercial barns. For example, software should be enhanced to automatically compare images and temperature.

Vision systems to predict animal weight and conformation

Frédéric Fortin and Patrick Gagnon,
Centre de développement du porc du Québec (CDPQ)

Three vision systems to predict animal weight and conformation were tested during this study. They all showed promise but would need to be improved for use on the farm.

Why was this work done?

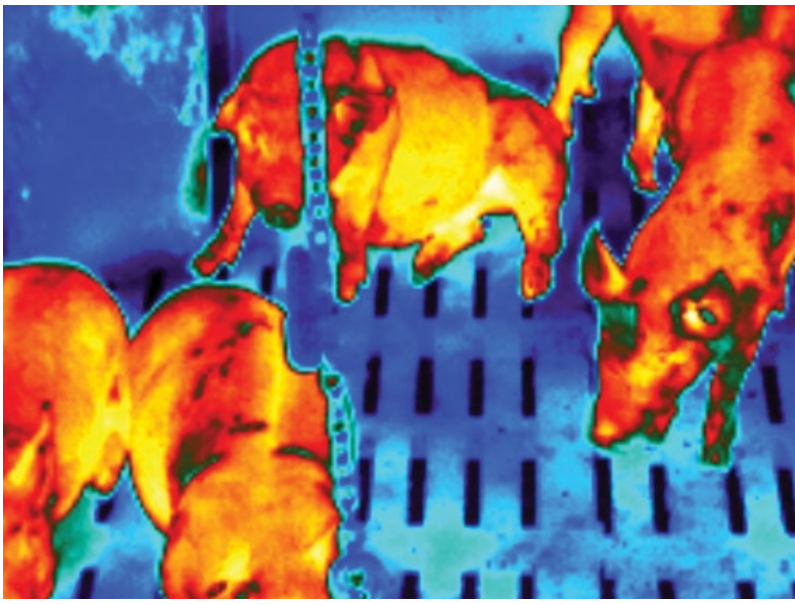
Predicting live weight, carcass weight and cut weights is of interest to assess the value of a hog. Computer vision tools provide the possibility to do so frequently for each pig, without any animal handling. The objective of this study was to test and evaluate different weight prediction systems in order to determine their ease of use, functionality and reliability on commercial farms.

What was done and what was the outcome?

The OptiSort hog sorter, based on a 2D image analysis, was first tested. The predicted weights provided by the OptiSort system were quite good compared to scale weights, but only for live weights up to about 105 kg.

A specific setup was then developed by CDPQ to collect images and create 3D models of live pigs. This setup consisted of three Kinect 2 cameras used simultaneously in a small pen designed to restrain a pig during scanning, which takes about one minute. Results showed that the vision system, in its current form, cannot provide accurate predictions of pig weight and conformation. Improving the 3D image capture setup and exploring ways to automate 3D image processing would be needed.

A portable device called PigWei was also tested. This technology was initially developed for Iberian pigs in Spain and was adapted to be effective with Canadian pig breeds. The PigWei instrument was found to be easy to use and practical. However, results showed that some improvements are still needed for the instrument to be practical in the commercial farm environment and effective with Canadian pig breeds.



Infrared imagery. Source: CCSI

Infrared thermography diagnostic platform for swine

Nigel Cook,
Alberta Agriculture and Forestry

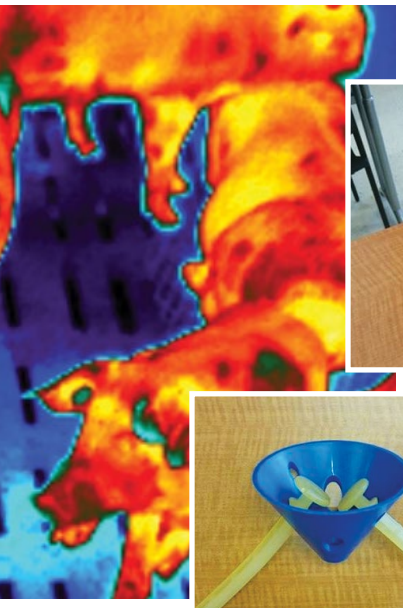
It is still inconclusive if infrared thermography (IRT) could be a useful tool to measure animal health or feed efficiency.

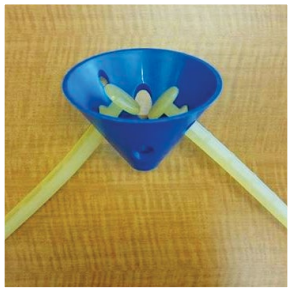
Why was this work done?

Infrared thermography (IRT) for medical applications was developed in the 1950s and has been adapted to many different areas since then. With this study, researchers aimed at developing approaches for using IRT to monitor pig performance, welfare, and carcass value.

What was done and what was the outcome?

An IRT system has been installed at the Lacombe Research and Development Centre (AAFC) pig barn to collect infrared thermography images. Several trials were carried out to evaluate the accuracy of IRT to identify sick pigs, classify animals based on feed efficiency and establish a relationship between temperature measured by IRT and stress. The data are still being analyzed.





Enrichment objects. Source: CCSI

Use of accelerometers to automatically assess pig behaviour and welfare

Jean-Paul Laforest,
Laval University

Researchers were unable to successfully automate the analysis of behaviour based on data collected by accelerometers attached to enrichment objects.

Why was this work done?

The use of live or video observation to measure behaviour and welfare in animals is time consuming and tends to be subject to human error. With this study researchers wanted to validate the use of accelerometers as tools to investigate pig behaviour as they interact with their environment.

What was done and what was the outcome?

Accelerometers were attached to different types of objects that were made available to pigs during the trials.

Results showed that the frequency and duration of the use of these objects decreased with time. For the suspended piece of wood, the decrease of use was considerably slower than for the other objects. Pigs seemed to like the piece of wood because of its destructible nature, which can also sustain interest overtime. Objects placed on the floor were manipulated more often if they were fixed. Results also showed that a daily wash of soiled objects or a daily replacement of destructible objects was unnecessary.

Finally, researchers were unable to successfully automate the analysis of behaviour based on the data collected by the accelerometers attached to enrichment objects. This method showed some potential, but much more work would be needed to improve the results compared to a video analysis.

Collaborators

Renée Bergeron	University of Guelph
Nicolas Devillers	Sherbrooke Research and Development Centre, AAFC

Use of 3D vision systems for rapid and objective hog carcass quality assessment

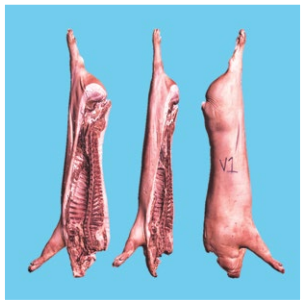
Candido Pomar,
Sherbrooke Research and Development Centre, AAFC

The 3D vision system was shown to be a promising tool to predict weight of primal, commercial and detailed cuts as well as meat weight and lean content. Algorithms are currently being developed using detailed data collected from this study.

Why was this work done?

In packing plants, the value of hog carcasses is currently being predicted by using simple measurements at a standardized site of the carcass. There are opportunities to use computer vision systems to more accurately assess not only carcass weight and leanness, but also the weight and lean yield of each carcass cut, allowing for efficient carcass sorting and valorization.

With this study, researchers wanted to test and validate a 3D portable scanner as a tool to assess carcass/cuts weight and leanness, and to calibrate the algorithms used to predict carcass quality.



Portable 3D scanner and carcass 3D models.
Source: AAFC

What was done and what was the outcome?

Researchers used a portable 3D scanner (GoScan50 by CreaForm) to capture 3D images of 200 half-carcasses. The carcasses were then split into primal cuts (loin, ham, shoulder, belly) and scanned independently. The carcass was then fully cut into commercial cuts according to the Canadian Pork Buyer's Guide (2011) and different measurements were taken on these cuts. Results obtained with this new scanner will be compared to results obtained from carcass dissection.

This study provided detailed data on 200 half-carcasses and analysis of this data is underway. Algorithms will be developed and automated to provide prediction models using 3D scanning, which will allow weight to be predicted for primal and commercial cuts as well as detailed cuts, meat weight (fat and lean) and lean content.

Near-infrared reflectance spectroscopy (NIRS).
Source: AAFC

Using near infra-red spectroscopy to predict carcass traits from pig ears

Manuel Juarez,
Lacombe Research and Development Centre, AAFC

Using near infra-red spectroscopy on carcass ears was successful in classifying carcasses according to their composition (different fat and lean contents) and certain meat quality attributes, including fatty acid composition.

Why was this work done?

Current methods to measure fat content and fatty acid composition are time consuming and costly. Near infrared reflectance spectroscopy (NIRS) is a sensitive, fast, and non-destructive technology that has shown great potential for predicting the fatty acid profile of fat.

With this study, the researchers' goal was to determine if NIRS data collected from pig ears could be used to classify carcasses according to various carcass traits.

What was done and what was the outcome?

Using NIRS, pig ears were scanned on live pigs as well as after slaughter. Carcass traits were measured and statistical models were developed. Using data collected after slaughter, statistical models allowed carcasses to be classified, with good accuracy, according to their fat and lean content as well as to certain meat quality attributes. However, when using data from live pigs, the accuracy was substantially lower.

Determining the age of bruises at slaughter

Luigi Faucitano,
Sherbrooke Research and Development Centre, AAFC

Using a spectrophotometer to assess the color of lesions demonstrates potential in objectively determining lesion age on the slaughter line.

Why was this work done?

Lesions are commonly assessed on the carcass using pictorial standards or by giving a score based on their number and type. However, no reliable technique exists for determining the age of skin lesions in pigs. As injuries can occur at any moment during the marketing process, knowing the time of infliction may be very helpful to reduce or prevent their occurrence. The objective of this study was therefore to develop objective methods to count, categorize and determine the age of bruises on pork carcasses on the slaughter line.

What was done and what was the outcome?

A trial involving animals was carried out, including mixing pens at four different times: one and two days before slaughter, in the truck and while waiting at the plant. An assessment of carcass lesions was then carried out.

Results showed that assessing the color of lesions with a spectrophotometer appears to be a suitable and rapid technique for discriminating between lesions less than seven hours old (occurring between loading and slaughter), and lesions that are more than 25 hours old (originating from the farm). Also, an analysis of gene expression and inflammation response in the skin lesion at slaughter supported the spectrophotometric color results obtained in this study. This relationship shows the potential of these techniques for the validation of line-speed, objective determination of lesion age.

Using a spectrophotometer to assess bruising colour on a carcass. Sabine Conte. Source: AAFC

Application of rapid methods for non-invasive assessment of pork quality - Nuclear Magnetic Resonance

Claude Gariépy,
Saint Hyacinthe Research and Development Centre, AAFC

Results of this study showed that nuclear magnetic resonance could be used to predict fat consistency in pork.

Why was this work done?

Pork with firm fat is generally what consumers and the pork industry are looking for. Conventional methods to determine fat consistency of meat, such as fat hardness, fatty acid composition, and unsaturated fatty acid content, are generally laborious, time-consuming, and destructive to the samples. Through this work, researchers investigated the possibility of determining parameters related to fat consistency, using time-domain nuclear magnetic resonance.

What was done and what was the outcome?

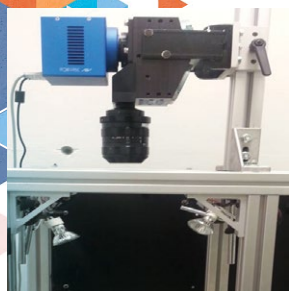
Solid fat content, which is an indicator of fat consistency, was measured by time-domain nuclear magnetic resonance at different temperatures. The solid fat content measurements were then correlated to fat hardness, fatty acid composition, and unsaturated fatty acids content.

Results showed that solid fat content measurements could be used to predict fat hardness, the content of some major fatty acids, and unsaturated fatty acids content in pork.

Collaborator

Marie-Rose Van Calsteren	Saint Hyacinthe Research and Development Centre, AAFC

Nuclear magnetic resonance equipment. Source: CCSI



Line-scan hyperspectral imaging system. Source: CCSI

Hyperspectral imaging for marbling assessment

Michael Ngadi,
McGill University

Results of this study showed that hyperspectral imaging was a promising technology for assessing marbling in pork and that further validation was required.

Why was this work done?

Intramuscular fat (marbling) is a key meat quality trait for most export and domestic markets. Conventional methods for determining intramuscular fat content in meat are not suited for applications on the slaughter line. With this study, researchers wanted to investigate the possibility of determining the intramuscular fat content by using near-infrared hyperspectral imaging.

What was done and what was the outcome?

A line-scan hyperspectral imaging system was designed at McGill University to mimic commercial conditions and was used to scan loin samples. Both frozen and thawed pork loins samples were analyzed with this system. Information about both the chemical properties (spectral) and physical properties (image texture) of the meat were extracted. This information was then compared to reference measurements to establish calibration models. Good correlations for marbling were obtained, for both frozen and thawed samples. However, further validation would be required.

Quick, non-invasive technology for predicting marbling in fresh loins

Frédéric Fortin,
Centre de développement du porc du Québec (CDPQ)

Results of this study showed that resistivity measurements did not correlate well with pork loin marbling.

Why was this work done?

Pork marbling is a key trait for slaughter plants but is not easy to predict accurately without cutting the loin muscle. Recent results indicate that induced current and resistance measurements could provide good predictions for loin marbling. The goal of this study was therefore to test a technology to predict marbling levels in uncut loins.

What was done and what was the outcome?

Standard measurements of marbling scores and drip loss were collected on 65 loin samples. These samples were then analyzed in an induced current measurement cell and sent to a commercial lab for intramuscular fat analyses. Results showed that this method did not demonstrate an adequate prediction of marbling. More research would be required.

Objective method for pork belly quality assessment and sorting

Bethany Uttaro,
Lacombe Research and Development Centre, AAFC

Results of this study suggested that:

- **The drop angle of pork belly could be utilized for sorting bellies based on firmness.**
- **Using normal behavior of bellies in response to gravity would be a simple solution to automate sorting for firmness.**

Why was this work done?

Soft fat poses a problem for bacon processing because the bellies are difficult to handle and to slice. Thus, processors manually assess bellies to sort out those that are unsuitable for bacon production. The objective of this study was to develop an instrument that could eventually lead to an automated system for belly firmness classification and sorting.

Assessing pork belly quality. Source: AAFC

What was done and what was the outcome?

Results from various trials suggested that the drop angle of pork belly could be utilized as a method for sorting bellies based on firmness. The following practical considerations were highlighted regarding the use of that method:

- High conveyor incline angles resulted in handling problems.
- The bending location of 24 cm from the caudal end of the primal belly appears to be appropriate for almost all bellies.
- Belly angle was related to floppiness assessments performed at the middle of the ribbed belly. It would therefore be possible to sort bellies for firmness very early on the production line.

A simple solution for automating the sorting of bellies appeared to be using their normal behavior in response to gravity as they exit a conveyor belt. Firm bellies would continue and be received by another conveyor, while very soft ones would bend and fall on a lower-level conveyor or bin below.

Commercial trials: Automated recording of individual water intake and of pig body temperature

Bernardo Predicala,
Prairie Swine Centre

Why was this work done?

Technologies developed or tested in pilot studies must be applied in environments closer to commercial conditions. In this context, Prairie Swine Centre (PSC) conducted preliminary commercial trials on two selected technologies:

- Individual water consumption system, and
- Infrared thermography system to measure body temperature

What was done and what was the outcome?

Both systems were installed in a grow-finish room. The smart drinkers were a simplified version of the one developed in the pilot study. Low-resolution infrared cameras were installed on top of drinkers in order to collect images of an individual pig while drinking. In addition, two high-resolution cameras were installed to provide group pictures.

To assess whether the two novel technologies were capable of detecting pigs that may be stressed due to routine husbandry practices, two types of stressors (exercising and mixing of unfamiliar pigs) were introduced. Depending on the stressor, results showed that water intake increased (exercising) or decreased (mixing). Data from the infrared thermography system showed that mixing unfamiliar pigs caused an increase in pig body temperature.

Further work on implementing these two novel technologies in other parts of the barn would be of interest, along with conducting an economic analysis.

Demonstration of using genomics to predict and enhance pig performance and carcass value

Brian Sullivan,
CCSI

Results of this demonstration showed that most genomic-estimated breeding values had a higher correlation with future phenotypes than traditionally estimated breeding values.

Why was this work done?

This project focused on the use of novel technologies to make it practical, affordable and accurate to measure various traits. Generated data can contribute to the application of genomics, especially for traits that are difficult or expensive to measure. The goal of this study was to compute genomic evaluations and demonstrate the potential for predicting and enhancing traits related to pig performance and carcass value.

What was done and what was the outcome?

Approximately 22,000 animals were genotyped for this study. Genomic evaluations were run on 19 traits, and various groups were used to validate the predictive value of progeny genomic estimated breeding values (GEBVs). The GEBVs were calculated before performance testing to validate the prediction accuracy of GEBV for future performance of pigs and compare it with predictions based on traditional BLUP evaluation of parents. Almost all GEBV showed higher correlation with adjusted phenotypes than EBVs.

Additional project information

Click on the links below for further information on this project

Links were last updated in 2022

R&D Featured Articles—by Geoff Geddes for Swine Innovation Porc

Articles may be found at: http://www.swineinnovationporc.ca/resources-e-newsletters.php

- Science Eyes Success with High-Tech Imagery - February 2020 (Vol. 4, No. 20.)
- Pork Belly Technology that's made to Measure - August 2019 (Vol. 4, No. 10.)
- When Wounds Talk, Researchers Listen - June 2019 (Vol. 4, No. 7.)
- PRRS Research Prompts Infectious Enthusiasm - June 2019 (Vol. 4, No. 5.)
- Genomics Lets Pork Industry Be Selective - April 2019 (Vol. 4, No. 2.)
- Listen Up: Pig Ears Help Predict Quality - March 2019 (Vol. 3, No. 26.)
- Grasping at Straw to Boost Sow Milk Yield - December 2018 (Vol. 3, No. 19.)
- Infrared Camera Could Keep Producers in the Black - October 2018 (Vol. 3, No. 14.)
- Good things Come in 3-D for Pork Researchers - August 2018 (Vol. 3, No. 10.)
- On Farm Automation Takes Off - July 2018 (Vol. 3, No. 7.)
- Pork Quality: how to Assess without the Mess - May 2018 (Vol. 3, No. 3.)
- High Hopes for Hi-Tech Pork Research - April 2018 (Vol. 3, No. 2.)

Farmscape Interviews:

- Wide Adoption of New Technology Brings Down Costs - March 12, 2019
- Emerging Technologies Help Improve Swine Productivity and Welfare - March 4, 2019
- Wider Adoption of Technology Reduces Costs, Improves Value - June 1, 2017

Farmscape Interviews:

- Adoption of Technology Key to Maintaining Competitive Positioning
  - May 10, 2017
- Novel Technologies Offer Opportunity to Improve Competitiveness
  - May 9, 2017
- Novel Technologies Being Adapted to Improve Competitiveness of Canadian Pork Industry
  - December 1, 2014

Peer-reviewed articles and abstracts:

2017

- Vitali, M., Conte, S., Lessard, M., Deschêne, K., Benoit-Biancamano, M.O., Celeste, C., Martelli, G., Sardi, L., Guay, F., Faucitano, L. (2017) Use of the spectrophotometric color method for the determination of the age of skin lesions on the pig carcass and its relationship with gene expression and histological and histochemical parameters. Abstract. *Journal of Animal Science, Vol. 95, Issue 9, September 2017, Pages 3873–3884.* DOI: https://doi.org/10.2527/jas.2017.1813

2016

- Huang, H., Ngadi, M. (2016) Prediction of pork fat attributes using NIR Images of frozen and thawed pork. Abstract. *Meat Science, Vol. 119: 51-61*.
  DOI: doi.org/10.1016/j.meatsci.2016.02.042

2015

- Prieto, N., Juárez, M., Dugan, M., López-Campos, O., Zijlstra, R., Aalhus, J. (2015) Could NIRS on ears be used to classify carcass composition in pigs? Abstract. *NIRS News, 26(8), 4-6.*
  DOI: doi.org/10.1255/nirn.1564

Additional resources:

2017

- Fortin, F., Gagnon, P., Maignel, L., Turgeon, J.G., Caron-Simard, V., Sullivan, B. (2017) Individual Water Intake Recording on Growing Pigs. Abstract and poster paper version. *68th Annual Meeting of the European Association of Animal Production, Tallinn, Estonia, September 2017.*
- Vitali, M., Conte S., Martelli, G., Lessard M., Faucitano, L. (2017) Which genes are best indicators for lesion age determination on the pig carcass? A preliminary study. Abstract and poster paper verison. *7th WAFL International Conference, Wageningen, The Netherlands, September 2017.*

2017

- Kucha, C., Liu, L., Ngadi, M., Gariépy, C., Maignel, L., (2017) Rapid assessment of pork solid fat content using hyperspectral imaging. Abstract and poster paper version. *68th Annual Meeting of the European Association of Animal Production, Tallinn, Estonia, September 2017.*
- Van Calsteren, M.R., Burelle, I., Cliché, S., Boucher, V., Jacques, L., Cossette-Tremblay, K., Ngadi, M., Fortin, F., Maignel, L., Gariépy, G. (2017) Relationship between fat hardness, fatty acid composition, and iodine value of pork backfat with solid fat content (SFC) determined by time-domain nuclear magnetic resonance (TD-NMR). Abstract and Poster paper version. *ISMAR Conference, Quebec City, July 2017.*

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2016

- Cook, N. (2016) Exploring novel technologies to optimize pig performance, carcass value and welfare. Presentation. *Banff Pork Seminar, January 12-14, 2016, Banff, AB.* Retrieved from: https://www.banffpork.ca
- Radio-Canada. (2016) Invention prometteuse pour l'industrie porcine. Video. *Published February 14, 2016.* Available from http://ici.radio-canada.ca/nouvelle/765174/industrie-porcine-viande-porc-nyx-dimensions
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- Prieto, N., Juárez, M., Zijlstra, R., López-Campos, Ó., Aalhus, J. (2015). Rapid authentication of enhanced quality pork by visible and near infrared spectroscopy. Abstract. *Meat Science, 99: 149.* DOI: 10.1016/j.meatsci.2014.07.010
- Rivest, J., Labrecque, M., Roy, M., Fortin, F. (2015) Individual water consumption system for growing-finishing pigs at Deschambault swine testing station. Abstract. *2015 Banff Pork Seminar Proceedings, Vol. 26, Abstract 13.* Retrieved from: https://www.banffpork.ca/proceedings/search/

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