Use of thermography in pigs: relationship between surface and core temperature

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Veterinaria Italiana 2021, **57** (1), 79-82. doi: 10.12834/VetIt.1077.5873.2
Accepted: 03.02.2020 | Available on line: 27.07.2021

Keywords
Animal welfare,
Body temperature,
Health status,
Infrared thermography,
Swine.

Summary
This study aims to assess the correlation between surface temperature estimated by infrared thermography and core temperature measured with rectal thermometer in weaning and fattening pigs. A total of 108 pigs were used in this study. Thermal images of the eye of each animal were recorded with a thermal imaging camera, rectal temperatures were measured using a calibrated digital thermometer. The average rectal temperature was 38.9 ± 0.4 °C (MIN = 37.9 °C; MAX = 40.1 °C) and the average eye temperature was 36.7 ± 0.1 °C (MIN = 34.8 °C; MAX = 38.8 °C). Our results showed that the mean eye temperature estimated by infrared thermography was significantly correlated (r = .581, P < .01) with rectal temperature. The correlation was significant and strong for weaners (r = .739, P < .01), significant although weak for fatteners (r = .236 P < .05). Thermography could be a valid method to estimate the core temperature of pigs under farm condition.

Consumer and European Union (EU) policy demand for consistent enforcement of welfare legislation in food producing animals has been increasing over the last decades. In response to this demand, the assessment of animal welfare at farm level needs to develop a science-based multidimensional approach (Mason and Mendl 1993). The welfare assessment aims at determining the actual status of animals, including both physical and mental state, using animal based indicators able to address areas of concern in this field (EFSA 2012a).

Several studies report that body temperature in pigs is a valid indicator for welfare assessment (Tosi *et al.* 2003, EFSA 2012b) and fever is the earliest and one of the main clinical signs of many diseases. However, body temperature is difficult to measure under farm conditions, as the accepted methods for measuring core temperature need handling and restraining of animals (Stewart *et al.* 2005).

Infrared thermography (IRT) is a non-invasive technique to estimate the body temperature by detecting infrared radiation emitted by each body (Mitchell 2013, Speakman and Ward 1998, Stewart *et al.* 2005). IRT uses thermal radiation emitted by objects to visualize and measure their surface temperature; based on thermal images it is possible to perform accurate temperature measurements (Speakman and Ward 1998). As IRT is a non-contact procedure, data can be collected on animals that are difficult to reach or to approach; furthermore, the short measuring time allows the recording of data from moving animals (Kastberger and Stachl 2003).

IRT has been used in several species. The medial posterior palpebral border of the lower eyelid and the curuncula lacrimalis has been demonstrated to be the location of the eye region showing the maximum temperature (pony: Johnson *et al.* 2011; cattle: Stewart *et al.* 2008; sheep: Stubsjøen *et al.* 2009).

Only a few studies have investigated the use of IRT in pigs and even fewer have investigated the use of IRT as a tool to identify increases in temperature (Bates *et al.* 2014, Schmidt *et al.* 2013, Traulsen *et al.* 2010).

The aim of the study was to assess the relationship between surface temperature estimated by IRT and core temperature measured with a rectal thermometer in weaning and fattening pigs.

The experimental protocol included only procedures of a common clinical examination and animals were kept in compliance with the EU Council Directive

2008/120/EC that stipulates minimum standards for the protection of pigs.

A total of 108 pigs (28 weaners of 47 day old and 80 fatteners of 232 day old) were used in this study. The experiment was carried out in the facilities of the Department of Veterinary Medical Sciences of the University of Bologna (Italy): pigs were kept in groups of 5 animals on a slatted floor and under controlled temperatures ranging from 20 to 27 °C, according to the age of animals. A clinical examination was performed before the measuring in order to exclude animals with clinical signs of diseases. Pigs received a commercial diet, according to the Consortium for Parma Ham production rules (Consortium for Parma Ham 2015), and water was available *ad libitum*.

Thermal images of the eye of each animal were recorded with a thermal imaging camera (Nec Avio TVS500). To optimize the accuracy of the thermographic image and to reduce sources of noise, before every work session the same image of a Lambert surface was taken to define the radiance emission and to nullify the effect of surface reflections on tested animals (Mallick *et al.* 2005). Only perfectly focused images were used. To determine the temperature of the eye, Grayess IRT Analyzer 4.8 (Informer Technologies, Inc., USA) was used and the maximum temperature (°C) within a circular area traced around the curuncula lacrimalis was measured (Figure 1). This maximum value was used for subsequent analysis. Rectal temperatures were measured using a calibrated digital thermometer, checked before the examination and compared to a certified mercury thermometer. In accordance with the manufacturer's instructions, the thermometer was inserted into the anus and positioned in contact with rectal mucosa for 10 seconds, until hearing the acoustic signal. During the measurements, animals were not manually restrained. For each animal the capture of thermal image was immediately followed by the measurement of rectal temperature; temperatures were recorded at the same time of the day. Frequency distributions and Pearson correlation between core and surface temperatures of the pigs were calculated. Cases of animals with rectal temperature higher than a reference limit (39 °C) were selected. Mean high temperatures of selected animals were compared to those of the other animals using a T test.

Data was normally distributed (Kolmogorov-Smirnov test) (IBM 2014): the average rectal temperature was 38.9 ± 0.4 °C (MIN = 37.9 °C; MAX = 40.1 °C) and the average eye temperature was 36.7 ± 0.1 °C (MIN = 34.8 °C; MAX = 38.8 °C). Our results showed that the mean eye temperature estimated by IRT was significantly correlated ($r = .581$, $P < .01$) with rectal temperature. The correlation was significant and strong for weaners ($r = .739$, $P < .01$), significant although weak for fatteners ($r = .236$ $P < .05$), showing that IRT can be reliably used on pigs of different ages (Figure 2).

We considered the eye region in agreement with IRT studies on different species, which have identified this location as the one that corresponds most to rectal temperature and that is less affected by other factors (Johnson *et al.* 2011, Stewart *et al.* 2008). The absence of hair around the eye allows heat dispersion that amounts to a greater emission of infrared radiation (Mitchell 2013). Chung and colleagues (Chung *et al.* 2010), comparing rectal and infrared thermometry in piglets, reported a significant linear relationship for surface temperature measured on three different locations of the body (central abdomen, cranial dorsum and perianal regions), while no significant relationship was found for lower eyelid. However, under farm conditions, the measurement at body regions such as flank and back may be negatively influenced by external factors, e.g., dirtiness, contact with other pigs and with the ground. On

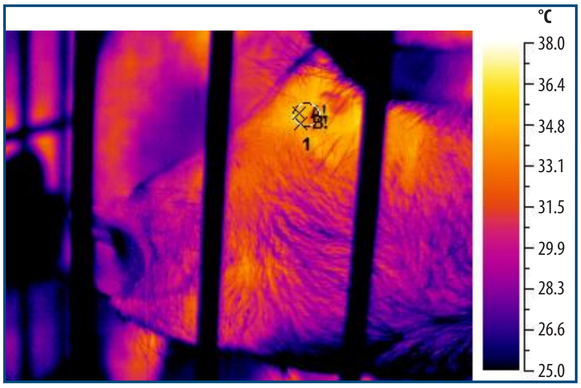

Figure 1. *Thermal image of a pig's head showing the position of the measurement point on the eye.*

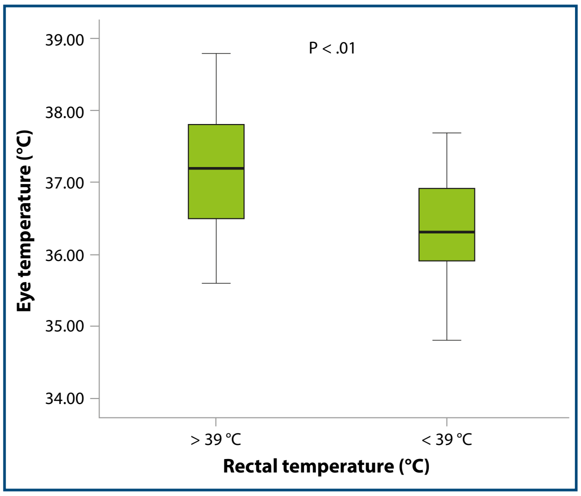

Figure 2. *Mean surface temperature estimated by infrared thermography in pigs of different ages with core temperature higher and lower than the reference limit (39 °C).*

the contrary, Schmidt and colleagues (Schmidt *et al.* 2013) measured body surface temperature in sows at different body regions and concluded that, under farm conditions, the back of the ear and the eye are the most promising locations to measure body temperature in pigs.

Our results suggested that IRT surface temperature measured at eye level is higher in animals with rectal temperature higher than the reference limit of 39 °C. Other studies on adult animals (Schmidt *et al.* 2013, Traulsen *et al.* 2010) reported a correlation between IRT body surface temperature and core temperature. A study on continuous IRT measurements (Schmidt *et al.* 2014) showed that surface temperature increase is time-delayed compared to the increase in core temperature, proving that IRT may not be an adequate early detection method. Nevertheless, studies in different species validate the use of IRT in assessing reaction to fear-induced stress (Dai *et al.* 2015, Stewart *et al.* 2008).

Our study suggests that IRT allows routine measurements of body surface temperatures that can be used for early disease detection. IRT applied at eye level is a valid method to estimate the core temperature of pigs under farm condition; however, the results should be interpreted with caution because of the limited sample size and further research is needed. Moreover, external environmental and physical conditions can negatively influence IRT measurements collected in the field and these factors need to be controlled in the design of experiments in order to have a clear interpretation of temperature outcomes (Church *et al.* 2014).

IRT might be a useful non-contact method to measure the core temperature of pigs under farm conditions, being valuable for a non-invasive assessment of physiological state and for monitoring pig welfare. Thermal imaging cameras are still relatively expensive, but appear to be reliable under field conditions and IRT provides instantaneous results since software for data analysis in real time is incorporated. Therefore, such a non-contact method would save time and reduce stress on the animals.

References

Bates J.L., Karriker L.A., Stock M.L., Pertzborn K.M., Balwin L.G., Wulf L.W., Lee C.L., Wang C. & Coetzee J.F. 2014. Impact of transmammary-delivered meloxicam on biomarkers of pain and distress in piglets after castration and tail docking. *PLoS ONE*, **9** (12), e113678. doi:10.1371/journal.pone.0113678.

Chung T., Jung W., Nam E., Kim J., Park S. & Hwang C. 2010. Comparison of rectal and infrared thermometry for obtaining body temperature of gnotobiotic piglets in conventional portable germ free facility. *Asian-Australas J Anim Sci*, **23**, 1364-1368.

Church J.S., Hegadoren P.R., Paetkau M.J., Miller C.C., Regev-Shoshani G., Schaefer A.L. & Schwartzkopf-Genswein K.S. 2014. Influence of environmental factors on infrared eye temperature measurements in cattle. *Res Vet Sci*, **96**, 220-226.

Consortium for Parma Ham. 1992. Prosciutto di Parma, Protected Designation of Origin. Specifications and dossier (http://www.prosciuttodiparma.com/pdf/en_UK/Specifications.pdf. accessed on 5 January 2015).

Dai F., Cogi N.H., Heinzl E.U.L., Dalla Costa E., Canali E. & Minero M. 2015. Validation of a fear test in sport horses using thermography. *J Vet Behav*, **10**, 128-136.

European Food Safety Authority (EFSA). 2012a. Statement on the use of animal-based measures to assess the welfare of animals. Panel on Animal Health and Welfare (AHAW). *EFSA Journal*, **10**, 2767.

European Food Safety Authority (EFSA). 2012b. Scientific Opinion on the use of animal-based measures to assess welfare in pigs. Panel on Animal Health and Welfare (AHAW). *EFSA Journal*, **10**, 2512.

IBM. 2014. IBM SPSS Statistics 22 Command Syntax Reference. IBM Corporation, U.S.A.

Johnson S.R., Rao S., Hussey S.B., Morley P.S. & Traub-Dargatz J.L. 2011. Thermographic eye temperature as an index to body temperature in ponies. *J Equine Vet Sci*, **31**, 63-66.

Kastberger G. & Stachl R. 2003. Infrared imaging technology and biological applications. *Behav Res Methods Instrum Comput*, **35**, 429-439.

Mason G. & Mendl M. 1993. Why is there no simple way of measuring animal welfare? *Animal Welfare*, **2**, 301-319.

Mallick S.P, Zickler T.E., Kriegman D.J. & Belhumeur P.N. 2005. Beyond Lambert: reconstructing specular surfaces using color. *In* IEEE Computer society conference on Computer vision and pattern recognition (CVPR'05), San Diego, CA, USA, 619-626. doi: 10.1109/CVPR.2005.88.

Mitchell M. 2013. Thermal imaging in physiology: theoretical and practical considerations. *In* Thermography. Current status and advances in livestock animals and in veterinary medicine (F. Luzi, M. Mitchell, L. Nanni Costa & V. Redaelli, eds). Fondazione Iniziative Zooprofilattiche e Zootecniche, Brescia, 47-65.

Schmidt M., Ammon C., Schon P.C., Manteuffel C. & Hoffmann G. 2014. The suitability of infrared temperature measurements for continuous temperature monitoring in gilts. *Archiv Tierzucht (Archives Animal Breeding)*, **21**, 1-12.

Schmidt M., Lahrmann K.H. & Ammon C. 2013. Assessment of body temperature in sows by two infrared thermography methods at various body surface locations. *J Swine Health Prod*, **21**, 203-209.

Speakman J.R. & Ward S. 1998. Infrared thermography: principles and applications. *Zoology*, **101**, 224-232.

Stewart M., Webster J.R., Schaefer A.L., Cook N.J. & Scott S.L. 2005. Infrared thermography as a non-invasive tool to study animal welfare. *Animal Welfare*, **14**, 319-325.

Stewart M., Schaefer A., Haley D.B., Colyn J., Cook N.J., Stafford K.J. & Webster J.R. 2008. Infrared thermography as a non-invasive method for detecting fear-related responses of cattle to handling procedures. *Animal Welfare*, **17**, 387-393.

Stubsjøen S.M., Flø A.S., Moe R.O., Janczak A.M., Skjerve E., Valle P.S. & Zanella A.J. 2009. Exploring non-invasive methods to assess pain in sheep. *Physiol Behav*, **98**, 640-648.

Tosi M.V., Canali E., Mattiello S., Ferrante V., Carenzi C. & Verga M. 2003. Il benessere dei suini e delle bovine da latte: punti critici e valutazione in allevamento. Fondazione Iniziative Zooprofilattiche e Zootecniche, Brescia.

Traulsen I., Naunin K., Müller K. & Krieter J. 2010. Application of infrared thermography to measure body temperature of sows. *Züchtungskunde*, **82**, 437-446.