Veterinary Integrative Sciences 2023; 21(1): 049 - 059x DOI; 10.12982/VIS.2023.005

Vet Integr Sci

Veterinary Integrative Sciences

ISSN; 2629-9968 (online)

Website; www.vet.cmu.ac.th/cmvj

Research article

Infrared Temperature Sensor for Use Among Sow Herds

Panuwat Yamsakul[1,*] Terdsak Yano[1], Kannika Na Lampang[2], Manad Khamkong[3] and Lertrak Srikitjakarn[4]

[1] Department of Food Animal Clinic, Faculty of Veterinary Medicine, Chiang Mai University, Chiang Mai 51000 Thailand
[2] Department of Veterinary Bioscience and Veterinary Public Health, Faculty of Veterinary Medicine, Chiang Mai University, Chiang Mai 51000 Thailand
[3] Department of Statistics, Faculty of Science, Chiang Mai University, Chiang Mai 51000 Thailand
[4] PODD center, Chiang Mai University, Chiang Mai 51000 Thailand.

Abstract

Presently, the body temperature of farm animals must be monitored to prevent the occurrence or progression of any disease amongst the herds. We have employed infrared sensors (called "Inspect") to detect the fever status of sows. Systemic architecture and data flow systems have also been designed for workers to use on small-scale pig farms. The body temperature of 100 gestating sows was determined with the use of a standard thermometer (inserted into the rectum), while our device was used on each part of the body of the sows. The valva or anus was found to be that location because of the high correlation that was observed between the two measurements (R=0.78). Moreover, regular, and systematic inspections were employed for a full year in 2019 on commercial pig farms that were home to at least 300 sows. The results indicated that the production indexes of the after period (2019) were better than those of the before period (2018), especially in terms of the health status of the animals with regard to mg/PCU. Consequently, it was determined that this system could detect abnormal signs in livestock before they could become a bigger problem.

Keywords: Body temperature, Infrared temperature sensor, Inspect, Sow

Corresponding author: Panuwat Yamsakul, Department of Food Animal Clinic, Faculty of Veterinary Medicine, Chiang Mai University, Chiang Mai 51000, Thailand. Tel: +6653-948023, Fax: +6653-948062, E-mail: panuwat.y@cmu.ac.th

Funding; This study was financially supported by the Vietnam National Foundation for Science and Technology Development (NAFOSTED) under Grant No. 106.05-2017.310.

Article history; *received manuscript: 4 June 2022,*
revised manuscript: 11 August 2022,
accepted manuscript: 11 November 2022,
published online: 16 November 2022
Academic editor; *Nguyen Trong Ngu*

INTRODUCTION

The swine industry continues to develop resulting in increased pig populations on farms. Consequently, it has become difficult to manage and monitor the health status of pigs. When swine farms transition into large holder pig farms, the operators of these swine farms must invest in a range of systematic advancements to improve upon management and to help them survey the health status of the pigs. For example, necessary investments related to cost production enhancements should include those associated with labor costs, feed costs, facilities costs of farm operations and also the cost of monitoring the health status of the animals or robust disease surveillance systems (Kim et al., 1995). Large swine farms have to control disease outbreaks because they can lead to high losses in production, which could impact large-scale farms far more than median or small holder pig farms. Thus, the operators of these pig farms need to prevent disease outbreaks and to continuously survey the threat of diseases upon their farms (Valdes-Donoso et al., 2018).

The first abnormal signs of potential infection by an agent is that a pig will have a fever or show a temperature change (Helwatkar et al., 2014). Therefore, body temperature can be a good indicator in the monitoring of the health status of these animals and in the monitoring of a potential outbreak of disease on a farm before it becomes a full blown event. This type of monitoring is commonly referred to as syndromic surveillance. The Participatory One Health Disease Detection (PODD) System involves the concept of initially monitoring the health of a single participant who can be assumed to represent all stakeholders along the chain of epidemiology. This is implemented by a user or reporter through the use of an application on a mobile phone (Yano et al., 2018). However, it can be very difficult to monitor the body temperature of a pig within a large farm. In the pig industry, farms are home to many pigs so it is difficult to monitor the body temperature of each pig by rectal temperature measurement. Rectal temperature measurement is commonly used to measure the temperature of farm animals because it is considered an extremely accurate form of monitoring an animals' temperature (Jang et al., 2015). However, rectal temperature measurement also contributes to a high risk of spreading disease agents to other pigs. This is because healthy pigs can become infected by the agent that can remain on the surface of this tool (Ludwig et al., 2007). Thus, the use of contact thermometers may be responsible for spreading infection on livestock farms.

That is why there is a need to develop a non-contact thermometer that could measure the animals' temperatures easily and quickly and without direct contact with the animals (Kim et al., 2003). Many researchers have reported that infrared technology can be used in non-contact thermometers to measure the temperature of animals (Loughmiller et al., 2001; Stewart et al., 2010; Soerensen and Pedersen, 2015). The concept of infrared thermometry (IRTM) involves the use of non-contact thermometers that can reduce or eliminate the need for direct contact between the thermometer and the animal, which is known to contribute to disease outbreaks among livestock. The implementation of IRTM can reduce the levels of stress animals incur as a result of the excessive amounts of handling and restraint that are often necessary on pig farms. Notably, these increased levels of stress can have an effect on both core and surface temperatures (Magnani et al., 2011). However, our device makes it easier to monitor an animal's body temperature and it can contribute to the creation of a more comprehensive automated monitoring system (Choudhury et al., 1986). IRTM offers many benefits, but there are still a number of weak points associated with it. Notably, there is a relationship between surface temperature and ambient temperature. Thus, the accuracy of the body temperature value can be influenced by incidental contact with some areas of the skin from which hair may be growing, which can influence the accuracy of the measurement recorded by IRTM (Henken et al., 1991). Moreover, body temperature measurements obtained from pigs will be very useful if a system is established that can make on-site assessments and then remotely report to vets who are assisting in the monitoring of the potential for disease outbreaks on farms.

Therefore, the objective of this study was to develop an infrared temperature sensor that does not involve contact with the animal, and also to combine it with an automatic wireless transmission system that can be used on sows.

MATERIALS AND METHODS

Experimental animals and trial farms

The body temperatures of one hundred gestating sows (Large White x Landrace), who displayed a variety of parity (parity 0-6 pass), were measured by inserting a thermometer into their rectums (by livestock digital thermometer SKU8278 obtained from the USA). Furthermore, each part of each sow's body was checked for body temperature in the mornings (07.00-08.00 am.) every day for 7 days using a temperature sensor developed by our team, which we call the Inspect. Body temperature measurements of the animal's forehead, shoulders, hips and anus/vulva were conducted. The experimental sows were then cared for by farm management systems that considered both feeding and management routines.

Area and type of farm

This study was performed at a commercial farm (home to at least 300 sows) in Lamphun Province in June of 2018. The animal housing unit was comprised of an open system that continually measured the environmental temperature. Data were recorded at the farm to establish a baseline of data. In 2019, we investigated the same pig farm that was home to 300 sows, where our device known as the Inspect was used to survey the animals and detect any illnesses in the pigs, especially with regard to the fever status of the animal population. Moreover, the body temperatures of the sows were accessed to recover the status of fever of the animals. At the end of 2019, pig production on the farm was summarized and compared with the findings for pig production in 2018.

Systemic architecture and data flow

Temperature measurement

Body temperatures of the animals were measured with the Inspect. Importantly, the Inspect was created and designed for farm workers because it is easy to use to measure the body temperatures of farm animals. The device incorporates an infrared sensor (MLX90614 module from Melexis, Italy). Its specifications include the following: a temperature range of -40 °C – 85 °C with a ± 0.5 °C margin of error in terms of accuracy. Moreover, the device also incorporates a four-digital tube module that can be used to record the ID of each sow. It also derives power from a power supply module AMS1117 that uses a 9-volt battery. The circuitry of the system is shown in Figure 1.

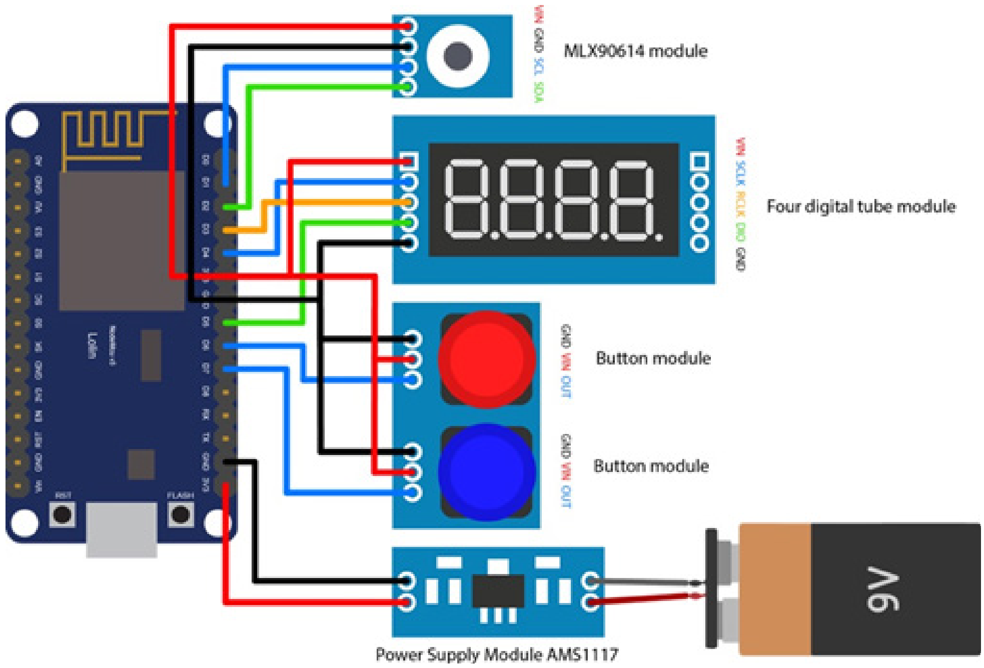

Figure 1 Circuitry of the Inspect used to measure the body temperature of sows.

Experimental design

Eight steps were employed for systemic architecture (Figure 2); 1) body temperature of the sow was measured by the Inspect (infrared sensor; MLX90614 module), 2) the body temperature signal was converted to digital signal data as NodeMCU or ESP-12, 3) the signal data was sent to the internet by a Wi-Fi access point, 4) the signal data was then sent to a PHP Server by HTTP request, 5) an API from the PHP server received the temperature data for analysis, 6) the temperature data was stored in MySQL, 7) the temperature data was categorized according to the degree of body temperature and the notification would then be sent to a veterinarian via a LINE notification if a sow had either a high or low temperature following determination of the animal's actual body temperature, and 8) The report would then be referred to as API from the PHP server for the data of MySQL to be displayed on the official website.

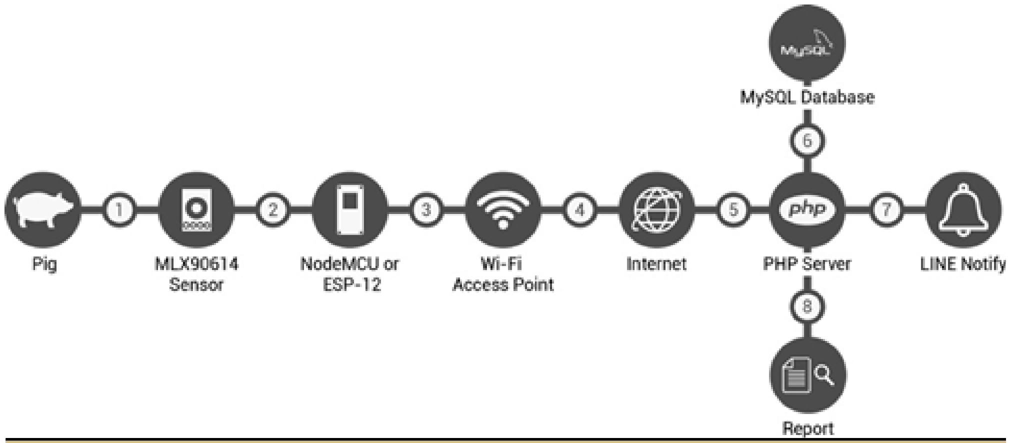

Figure 2 Circuitry of the Inspect used to measure the body temperature of sows.

Data acquisition

The body temperatures of one hundred sows were recorded in the morning for 7 days using the Inspect. On the first and the last day of the experiment, records of each sow was analyzed the accuracy of the Inspect. Readings were taken on each part of the sow to be compared with the rectal temperature of the animal that was recorded with a standard thermometer. Moreover, the room temperature at that time was recorded for the purposes of comparing all relevant conditions.

Using for sow into the pig farm

In 2019, a commercial pig farm was selected for field trail of using inspect to replace from rectal temperature measurement by 30% of body temperature of sow were randomly measured by the inspect. The pig production of farm was recorded and reported by excel program. The amount of pig production of 2019 (using the inspect) was compared with the pig production of 2018 (using the rectal temperature measurement) for indicated the efficacy of different tools.

Statistical analysis

Room temperature was measured accordingly, while the body temperature of each sow was measured and then analyzed by descriptive analysis. Data of body temperature recorded on each part of the sow were entered into an Excel database (Microsoft Excel, 2013, Microsoft Corporation, USA) to identify any correlation with body temperature recorded by rectal measurement using a standard thermometer. Moreover, a comparison of the production indexes of sows on this farm was conducted between 2018 and 2019. The data were further compared by descriptive analysis.

RESULTS

Infrared sensor (the Inspect)

The box of the Inspect (Figure 3) is composed of a green button that serves as an on and off switch. The black lens represents the infrared sensor. The red button indicates the measured temperature. The green button represents the changing mode of action. Lastly, there is a four-digital display window.

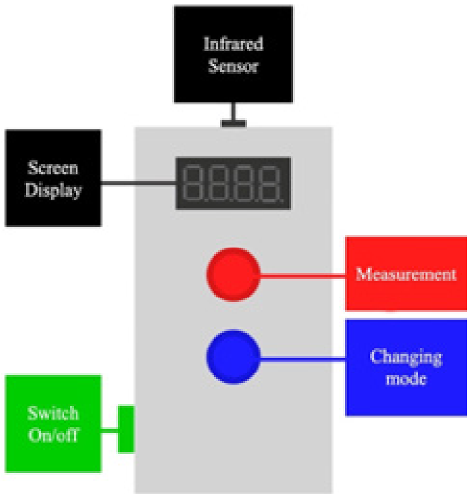

Figure 3 Infrared sensor (the Inspect).

The optimal body part of the sow selected for measurement of body temperature

The body temperatures of one hundred sows were measured both by digital thermometer and by using the Inspect. Both of the body temperature results are showed in Table 1.

Table 1 Correlation (R) of body temperature measured using a digital thermometer and body temperature measured using the temperature sensor (the Inspect) on each part of body of the sow.

	Digital thermometer	Infrared sensor (Inspect)			
	Anus	Forehead	Shoulder	Hip	Anus/Valva
Anus	1				
Forehead	0.25	1			
Shoulder	0.15	0.88	1		
Hip	0.45	0.66	0.53	1	
Anus/Valva	0.78	0.53	0.37	0.55	1

Production indexes of sows on the farm between 2018 and 2019

The production indexes of sows on this farm were recorded in 2018, which was considered as using rectal temperature measurement, while the production indexes of sows on this farm were recorded in 2019, which was considered as using the inspect. The production indexes of the sows on this farm between 2018 and 2019 were compared by descriptive analysis as is shown in Table 2.

Table 2 Comparison of production indexes of sows between 2018 and 2019 (indexed by year)

Production indexes	2018 (using rectal temometer)	2019 (using inspect)
Average Breeding group size; animals/month	49.75	57.83
%Return to service	8.93	9.01
Number of farrowing sow; animals/month	89.23	88.47
Litter size; animals/sow	10.33	11.58
%Still birth	6.75	7.76
%Mummy	1.70	1.91
Average born alive; animals	9.64	10.45
Pig wean/sow; animals	8.99	9.11
Average Weaning weight; kg	7.23	7.42
%PWM	11.49	8.21
%Culling	26.97	26.18
Number of sows	196.50	233.00
AI of amoxicillin using (mg of sow)	3,072,000.00	3,364,000.00
PCU = population * AW	101,280.00	126,480.00
mg/PCU	30.33	26.60
Animal welfare issue	poor	good

Abbreviations: PWM; pre-weaning mortality, AI; active ingredient, PCU; population correlation unit, AW; average weight at treatment, mg; milligram.

DISCUSSION

Presently, the body temperature measurements of pigs are usually accomplished by using a standard thermometer that is inserted into the rectum. In fact, these thermometers can be very difficult to use for the workers o these pig farms. Not only does the handling and restraint of the animal result in increased levels of stress in the pigs, but it also presents the risk of spreading infection to other animals via the equipment being used (Mccafferty, 2007). Consequently, the use of an infrared thermometer can address these problems because its administration involves the use of non-contact temperature measurement methods, which can be much easier for workers to administer (Loughmiller et al., 2001). The infrared sensor of the Inspect is a method of temperature measurement that was designed and created for workers to use on pig farms. This device is not only easier to use, it also decreases the risk of spreading infection via the potential transfer of agents. Moreover, infrared temperature still be concern animal welfare when compare with rectral temperature measurement.

The systemic architecture of the measurement system used to measure the body temperatures of sows by infrared sensor was found to be stable. This monitoring system can be referred to as a syndromic surveillance system that can effectively monitor the fever status of sows. For the purposes of data flow, patterns of syndromic surveillance were employed to monitor clinical signs, analyze data, notify stakeholders and also to make relevant assessments after the intervention was completed (Dominic, 2019).

Moreover, Jang et al. (2015) reported that automated systems that are used to monitor pig body temperatures are a very important tools because they can help determine the health of the animal. Infrared sensors have been employed to monitor the body temperature of sows. Additionally, it has been reported that body temperature monitoring systems can be used to determine a number of other abnormalities. That is because the back temperature of the sow can be used to quickly and easily monitor the animals' potential fever status using infrared sensors. Furthermore, infrared sensors are not only more efficient but are also easier to use for workers on pig farms.

The body temperature recorded by digital thermometer was used as the standard temperature, and it was compared with the temperature recorded at each part of the body by infrared sensor (the Inspect). As can be seen in Table 1, the separation in body temperature on a digital thermometer recorded by inserting a thermometer into the anus of the animal and the body temperature of the animal recorded by infrared sensor or the Inspect via the anus/valvar was 0.78, which was considered relatively high.

Nevertheless, some problems have been identified when using an infrared thermometer on pigs. Notably, thermoregulatory ability in pigs increases with age (Manners and McCrea, 1963) and that is why it is important to find out which part of the body of a pig is correlated with an accurate reading of body temperature measurement when using a standard thermometer. Table 1 shows that the body temperature measurement of a sow using a standard thermometer correlates with the body temperature measurement of the anus/valva of the sow when using the Inspect. In a previous study, the surface temperature of the skin (either hairy or bare skin) can interfere with certain environmental ambient factors. This occurs because the thermoregulatory response of the body that helps in maintaining a stable body temperature can be influenced, especially in adult pigs such as with fattened pigs or sows (Soerensen and Pedersen, 2015). Moreover, the adult pigs of some breeds, such as the Duroc, can have a lot of hair. Therefore, a degree of accuracy of body temperature measurement is required and there is a need to find an area of the body that does not have hair growing on it such as the anus or valva. That is why the R-square value was used after comparison between the body temperature measurement using a standard thermometer inserted into the rectum of the animal and the infrared sensor of the Inspect that was used at the anus/valva. Therefore, the infrared sensor should be used to measure body temperature on or around the anus/valva area.

According to Table 2, the production indexes of the after period were considered better than those of the before period, especially with regard to the production indexes recorded by our disease surveillance system; %PWM, mg/PCU and animal welfare issue also.

It is clear that the production indexes of the after period were better than those of the before period, especially with regard to the production indexes directly concerned with the health status of these farm animals (Table 2). Notably, the use of a sensor can help detect abnormal signs before they become problematic in the form of a disease outbreak. Undeniably, any implement that can assist in the early detection of a possible disease outbreak would be extremely beneficial. This would be referred to as a form of syndromic surveillance. Usually, the system requires a participant, identified as the reporter, who remotely sends the data as a clinical sign from the animal to a more comprehensive and sophisticated system such as the PODD system (Yano et al., 2018). The efficacy of the surveillance system is noteworthy especially in terms of its accuracy through the use of a sensor. The sensor system has been used in surveillance systems developed by other researchers such as Hentzen et al. (2012), who reported that wireless temperature measurement systems can be used for the detection of fever status in sows. Furthermore, Andersen et al. (2008) used an ear tag temperature sensor to detect the surface temperature of sows. Moreover, many researchers have used infrared sensors to detect the body temperatures of pigs in their research work in a attempt to establish a method of early detection for an abnormal status (Libo et al., 2010; Bai et al., 2014; Qin, 2015; Li, 2017). A surveillance system of this type can be used in the early detection of abnormal signs obtained from animals that could significantly improve the production of these farm. However, our system can still be used as a manual method with minimal levels of training or experience needed by farm workers. Thus, going forward, a surveillance system with sensors should be further developed in terms of accuracy as an automatic method of monitoring the health status of farm animals.

CONCLUSIONS

In conclusion, body temperature can be used as an important indicator to assess the health status of pigs and to also diagnose the presence of pig diseases. Our study employed an infrared sensor for the effective detection of the health status of sows. The optimum location of the sow's body for recording temperature is the valvar or anus, which produced similar results to that of the temperature measurement established by a standard thermometer. Moreover, our system can identify normal and abnormal body temperature extremely quickly, which would mean that the outbreak of a disease would be stopped resulting in a significant decrease in losses in pig production. Non-contact infrared temperature measurement technology is an essential aspect in the development of smart agricultural tools. The development of these types of intuitive tools are part of a trend that is presently expanding to replace traditional manual temperature measurement methods. However, sophisticated sensor systems should be developed and integrated with the use of artificial intelligence or AI for the benefit of smart agricultural advancements in the future.

ACKNOWLEDGEMENTS

This study was supported by Padet Farm Lamphun in Thailand for housing of sows, and their assistance in sample collection. We are also grateful to workers in the IPST company limited, Chiang Mai, Thailand for technical support.

AUTHOR CONTRIBUTIONS

The authors confirm contribution to the paper as follows: study conception and design: Panuwat Yamsakul and Lertrak Srikitjakarn; data collection: Panuwat Yamsakul and Terdsak Yano; analysis and interpretation of results: Panuwat Yamsakul, Kannika Na Lampang and Manad Khamkong; draft manuscript preparation: all authors. Finally, all authors reviewed the results and approved the final version of the manuscript.

REFERENCES

Andersen, M.L., Jørgensen, E., Dybkjær, L., 2008. The ear skin temperature as an indicator of the thermal comfort of pigs. Appl. Anim. Behav. Sci. 113(1-3), 43–56.

Bai, G., Liu, L., Shen, M., Yao, W., Yang, X., 2014. Design of sow body temperature monitoring node based on wireless sensor network. J. Nanjing Agric. Univ. 37(5), 128-134.

Choudhury, B.J., Reginato, R.J., Idso, S.B., 1986. An analysis of infrared temperature observations over wheat and calculation of latent heat flux. Agri. For. Meteorol. 37(1), 75-88.

Dominic, R., 2019. Finding outbreaks faster: metrics for one health surveillance. Available online: https://www.salzburgglobal.org/multi-year-series/outbreaks/pageId/9045.

Helwatkar, A., Riordan, D., Walsh, J., 2014. Sensor technology for animal health monitoring. In Proceedings of the 8th international conference on sensing technology, Liverpool, UK, 2-4 September 2014.

Henken, A.M., Brandsma, H.A., Vanderhel, W., Verstegen, M.W.A., 1991. Heat-balance characteristics of limit-fed growing pigs of several breeds kept in groups at and below thermal neutrality. Anim. Sci. J. 69, 2434–2442.

Hentzen, M., Hovden, D., Essen, G.V., 2012. Design and validation of a wireless temperature measurement system for laboratory and farm animals. In Proceedings of measuring behavior, Utrecht, 28-31 August 2012, pp. 466-471.

Jang, J.C., Lee, M.H., Lee, J.Y., Choi, H.C., Choi, D.Y., Kim, H.J., Kim, H.T., 2015. Monitoring pig body temperature using infrared sensors. Biosyst. Eng. 40(4), 368-372.

Kim, Y.J., Lee, D.Y., Han, K.H., 2003. Clinical studies for the development of non-contact thermometer to take easily the body temperature of domestic animals. J. Vet. Clin. 20(3), 357-363.

Kim, S.G., Kwak, K.B., Kim, T.K., 1995. Effects of scale expansion by automatization in pork production. Korean J. Environ. Agric. 11(1), 125-138.

Li, C., Tong-hui, Q., Shi-zhen, Z., Guang-xu, Z., 2017. Design of pig signs and breeding environment monitoring system based on wireless sensor network. Tech. Auto. Appl. 36(5), 61–64.

Libo, G., Gang, D., Gefen, Y., Fengcai, Z., Linfu, Y., Guishu, Y., 2010. Trial effect of infrared thermometer in body temperature screening of pig slaughterhouse. China. Anim. Husb. Vet. Med. 37(9), 235–237.

Loughmiller, J.A., Spire, M.F., Dritz, S.S., Fenwick, B.W., Hosni, M.H., Hogge, S.B., 2001. Relationship between mean body surface temperature measured by use of infrared thermography and ambient temperature in clinically normal pigs and pigs inoculated with Actinobacillus pleuropneumoniae. Am. J. Vet. Res. 62, 676–681.

Ludwig, N., Gargano, M., Luzi, E., Carenzi, C., Verga, M., 2007. Technical note: applicability of infrared thermography as a non invasive measurement of stress in rabbit. World Rabbit Sci. 15, 199–205.

Magnani, D., Gatto, M., Cafazzo, S., Stelletta, C., Morgante, M., Costa, L.N., 2011. Difference of surface body temperature in piglets due to the backtest and environmental condition. In Conference proceedings of international society for animal hygiene, Vienna, 3-7 July 2011, pp. 1029–1032.

Manners, M.J., McCrea, M.R., 1963. Changes in the chemical composition of sow-reared piglets during the 1st month of life. Br. J. Nutr. 17, 495–513.

Mccafferty, D.J., 2007. The value of infrared thermography for research on mammals: previous applications and future directions. Mamm. Rev. 37, 207–223.

Qin, Y., 2015. Research on pig body temperature collection system based on infrared temperature measurement equipment". Information technology branch of China animal husbandry and veterinary society. In Proceedings of the 10th symposium of information technology branch of China animal husbandry and veterinary society, China, pp. 2245.

Valdes-Donoso, P., Alvarez, J., Jarvis, L.S., Morrison, R.B., Perez, A.M., 2018. Production losses from an endemic animal disease: porcine reproductive and respiratory syndrome (prrs) in selected Midwest Us sow farms. Front. Vet. Sci. 5, 102.

Soerensen, D.D., Pedersen, L.J., 2015. Infrared skin temperature measurements for monitoring health in pigs: a review. Acta. Vet. Scand. 57, 5.

Stewart, M., Webster, J.R., Stafford, K.J., Schaefer, A.L., Verkerk, G.A., 2010. Technical note: effects of an epinephrine infusion on eye temperature and heart rate variability in bull calves. J. Dairy. Sci. 93, 5252–5257.

Yano, T., Phornwisetsirikun, S., Susumpow, P., Visrutaratna, S., Chanachai, K., Phetra, P., Chaisowwong, W., Trakarnsirinont, P., Hemwan, P., Kaewpinta, B., Singhapreecha, C., Kreausukon, K., Charoenpanyanet, A., Robert, C.S., Robert, L., Rodtian, P., Mahasing, S., Laiya, E., Pattamakaew, S., Tankitiyanon, T., Sansamur, C., Srikitjakarn, L., 2018. A participatory system for preventing pandemics of animal origins: pilot study of the participatory one health disease detection (PODD) system. JMIR. Public. Health. Surveill. 4(1), e25.

How to cite this article;

Panuwat Yamsakul, Terdsak Yano, Kannika Na Lampang, Manad Khamkong and Lertrak Srikitjakarn. Infrared Temperature Sensor for Use Among Sow Herds. Veterinary Integrative Sciences. 2023; 21(1): 49- 59.