ISSN 2175-6813

Revista Engenharia na Agricultura

Viçosa, MG, DEA/UFV - DOI: 10.13083/reveng.v30i1.15461 v.31, p.120-126, 2023

ESP8266 MODULE USE IN ANIMAL PRODUCTION: A REVIEW

Hiago Henrique Rocha Zanetoni[1]*, Maria Angela de Souza[2], Charles de Oliveira Paranhos[2], Daniel Marçal de Queiroz[2] & Fernanda Campos de Sousa[2]

1 - Federal University of Rondonópolis, Institut of Agricultural and Technological Sciences, Rondonópolis, Mato Grosso, Brazil

2 - Federal University of Viçosa, Departament of Agricultural Engineering, Viçosa, Minas Gerais, Brazil

Keywords:
Digital agriculture
Internet of things
Animal production
Decision making

ABSTRACT

The thermal environment in livestock buildings affects the productive and reproductive performance of animals. Therefore, monitoring thermal environment variables is necessary. This study reviewed the applicability of the electronic device ESP8266 module to monitoring animal production. The ESP8266 module is a microcontroller that enables the collection, storage and transmission of data that influence livestock production. The data collected are transferred to cloud computing systems allowing the development of supervisory systems that can be accessed by smartphones, tablets or computers. With this type of microprocessor, it is possible to develop autonomous management systems for animal production. Connected devices using the internet of things, artificial intelligence, machine learning and blockchain will facilitate the analysis of data from the production chain and the appropriate decision-making. Managers of livestock production systems will be in charge of following up and monitoring the processes.

Palavras-Chave:
Agropecuária digital
Internet das coisas
Produção animal
Tomada de decisões

USO DO MÓDULO ESP8266 NA PRODUÇÃO ANIMAL: UMA REVISÃO

RESUMO

O ambiente térmico nas instalações de produção animal afeta o desempenho produtivo e reprodutivo dos animais. Em virtude disso, é preciso monitorar as variáveis ambientais do sistema. Neste estudo, buscou-se demonstrar a aplicabilidade de um dispositivo eletrônico, o módulo ESP8266, para monitoramento da produção animal. O módulo ESP8266 é um microcontrolador que possibilita a coleta, armazenamento e transmissão de dados que impactam na produção animal. Os dados coletados podem ser transferidos para sistemas de computação em nuvem permitindo o desenvolvimento de sistemas supervisórios que podem ser acessados por smartphones, tablets ou computadores. Com a utilização desse tipo de microprocessador é possível se desenvolver sistemas autônomos de manejo da produção animal. Os equipamentos conectados, com apoio da internet das coisas, inteligência artificial, aprendizado de máquina e blockchain poderão facilitar a análise dos dados da cadeia produtiva e a tomada das decisões cabíveis. Aos gerentes dos sistemas de produção animal caberá o acompanhamento e monitoramento dos processos em curso.

Received 27 Feb, 2023 • Accepted 15 May, 2023 • Published 08 Aug, 2023

Email (corresponding author)*: hiagozanetoni@gmail.com

SECTION EDITOR IN CHARGE

Daiane Cecchin

INTRODUCTION

The productivity of animal production systems has increased significantly in recent years as the result of technological advances and investments in genetic improvement, nutrition, health, management and ambience. These advances came about to increase the world production of foods of animal origin with improved efficiency and sustainability. To achieve greater production efficiency, it is important to consider animal welfare, since animals in thermally favorable environments tend to express their maximum productive potential (Gonzalez-Rivas et al., 2020).

A thermally favorable environment is defined as temperature and relative humidity in adequate ranges for animal development, i.e., animals will not suffer from extreme heat or cold (Baêta & Souza, 2010). When exposed to high ambient temperatures, animals maintain homeothermy through physiological and behavioral changes (Hoffmann et al., 2020; Baêta & Souza, 2010). In this condition, there may be decrease in feed intake, increase in water consumption, increase in respiratory rate to increase heat exchanges via the latent pathway, vasodilation to increase blood irrigation under the skin and optimize animal-to-environment heat exchanges by both conduction and convection. In an inverse condition, with animals in ambient temperatures below comfort level, feed consumption increases to increase the metabolic heat production, vasoconstriction, and piloerection to reduce the heat dissipation by convection (Baêta & Souza, 2010). These physiological changes have an energy cost, resulting in decrease in production, decrease in intensity of estrus and pregnancy in females, decrease in the production of viable sperm in males, and harming animal health (Becker et al., 2020; Burhans et al. al., 2022; Polsky & Von Keyserlingk, 2017; Roth, 2020). Providing a favorable thermal environment in animal production buildings is thus vital for animal production performance (Tong et al., 2019), since comfortable conditions allow them to maintain homeothermy, which reduces energy expenditure and improves productivity (Chen et al., 2021; Gonzalez-Rivas et al., 2020).

In this sense, the animal production environment must be monitored and controlled, given its relationship with the productivity of housed animals. The Internet of Things (IoT) has brought good results to farmers who bet on this technology, optimizing the use of natural resources, inputs and energy. It is a system of interconnected electronic devices, machines, objects, animals and/or people that are provided with a unique identifier and capable of transferring data over a network, which can be fixed or mobile. The ESP8266 module and its variants are used to exchange data between the devices that make up the IoT and the web server (Ruiz-Ortega et al., 2022). As a means to highlight the results brought by IoT to animal production, the objective of the present study is to describe the applicability of the ESP8266 module in these systems.

INTERNET OF THINGS

The concept of Internet of things (IoT) was first implemented in a supply chain in mid-2008. However, this type of wireless system, which uses Wi-Fi, was used for the first time in 1990. Since its creation, this system has been widely disseminated due to its low cost and ability to operate on common frequencies (Pereira et al., 2020). For a device to be part of the IoT, it must be connected to the internet, regardless of the connection method used. Therefore, it is possible to collect and share data in real time autonomously with no human intervention. It is also possible to use IoT devices in supervisory systems that provide a graphical interface, allowing the user to monitor in real time the environmental conditions of the animal production system, thus becoming a tool to support the decision-making process.

The monitoring of environmental variables inside animal production buildings is based on sensors to collect data. Sensors are electronic devices that sense the variation of a physical quantity and are capable of reading data manually or automatically (Thomazini & Albuquerque, 2020). However, they have limitations of usability and response time in decision-making in view of the need for collection, tabulation and analysis of data for later decision-making regarding the control of the environment. Low-cost IoT-based devices are alternatives to limitations that facilitate data acquisition and the decision-making process (Kumar et al., 2019). IoT-based devices enable the monitoring of the thermal environment and animal production in real time (Michie et al., 2020).

ESP8266 MODULE

IoT implementation requires the integration of sensors and devices connected to the internet using wired or wireless networks. Therefore, the devices must be compatible with this technology. The ESP8266 module is a system with a single integrated circuit (system-on-chip or SOC) and built-in Wi-Fi (Ceja et al., 2017). The ESP8266 module is manufactured by the company Espressif Systems®, available since 2014. It was created to be used as a Wi-Fi bridge between microcontrollers and the web server (Ceja et al., 2017).

ESP8266 is a 32-bit microcontroller that includes connectors, buses, flash memory, input and output ports, internal temperature sensor, 3.3 V operating voltage, 80 MHz processor and Integrated TCP/IP protocol stack, which allows connection to Wi-Fi network (Rawlins et al., 2022).

The microcontroller architecture can feature a variety of applications and there are different variants based on the ESP8266 module (Table 1). The selection of the variant may depend on funds available for purchasing, since the module price changes according to variant. In addition, the selection may be related to the processing power of the module, as it also differs between variants.

ESP8266 has both processing and storage integrated and is compatible with development platforms, speeding up programming (Espressif Systems, 2022; Hlaing et al., 2017). The ESP8266 module configuration can be performed by the

Table 1. Features of the ESP8266 variants

ESP8266 Variant	Features
ESP-01	Dimensions: 14.30 mm × 24.80 mm; 8 pins between power and GPIO; unshielded PCB antenna; 3.3V; newer versions include the ESP8266EX and the early models of the first ESP8266 (without EX).
ESP-02	Dimensions: 14.20 mm × 14.20 mm; 8 surface connections; no antenna on board, but with external antenna connector; unshielded; 3.3V.
ESP-03	Dimensions: 17.30 mm × 12.10 mm; 14 surface connections; ceramic antenna; unshielded; 3.3V.
ESP-04	Dimensions: 14.70 mm × 12.10 mm; 14 surface connections; no antenna; shielded; 3.3V.
ESP-05	Dimensions: 14.20 mm × 14.20 mm; 8 pins; no built-in antenna, external antenna connector; shielded; 3.3V.
ESP-06	Dimensions: 14.20 mm × 14.70 mm; 12 under-board connections; no antenna; shielded; 3.3V.
ESP-07	Dimensions: 20.00 mm × 16.00 mm; 16 surface connections; ceramic antenna or connector for external antenna; shielded; 3.3V.
ESP-08	Dimensions: 17.00 mm × 16.00 mm; 16 surface connections, no antenna; shielded; 3.3V.
ESP-09	Dimensions: 10.00 mm × 10.00 mm; 18 under-board connections; no antenna; unshielded; 3.3V.
ESP-10	Dimensions: 14.20 mm × 10.00 mm; 5 surface connections; no antenna; unshielded; 3.3V.
ESP-11	Dimensions: 14.20 mm × 10.00 mm; 5 surface connections; no antenna; unshielded; 3.3V.
ESP-12	Dimensions: 24.00 mm × 16.00 mm;16 surface connections; PCB antenna; shielded; 3.3V.
ESP-12-E/F	Dimensions: 24.00 mm × 16.00 mm; 22 surface connections arranged on three sides (8+8+6); PCB antenna; shielded; 3.3V.
ESP-13	Dimensions: 18.00 mm × 20.00 mm; 18 surface connections; PCB antenna; shielded; 3.3V.
ESP-14	Includes a STM8 that controls the ESP8266 via AT commands; Dimensions: 24.30 mm × 16.20 mm; 22 surface connections; PCB antenna; shielded; 3.3V.
ESP-WROOM	Dimensions: 18.00 mm × 20.00 mm;18 surface connections; PCB antenna; shielded; 3.3V.
NodeMCU	Based on ESP-12; Dimensions: 30.85 mm × 47.35 mm; 30 pin and USB; PCB antenna; shielded; 3.3V and 5V; user and programming buttons (flash).
ESP-201	Dimensions: 26.00 mm × 33.50 mm and 26 pins.

Source: Adapted from Ceja et al. (2017)

Arduino programming IDE software using the C or C++ language, but other languages can be used, such as MicroPython, Go, Lua and JavaScript (Rawlins et al., 2022).

Therefore, one can see that IoT applications, in which sensors measure magnitudes in real time, Wi-Fi serial modules such as ESP 8266 are important in the system, allowing data transmission. Data can be accessed or processed to support the decision-making process. The module with its Wi-Fi connection provides real-time access to the internet and enables data transmission. This module is designed to operate as a serial-Wi-Fi bridge, making the connection required, that is, on the one hand, it receives the command via serial, on the other hand, it interacts with the Wi-Fi network through its connections.

APPLICATION OF ESP8266 IN AGRICULTURE

Integrating sensor with ESP8266 module and computer interface enables long-distance tracking and monitoring of the environmental variables in animal production. It only requires a system built with a sensor, to measure the variable, coupled to a Wi-Fi ESP8266 serial module for data transmission, and the software for handling and viewing data. ESP8266 can also execute tasks on the system such as activate the ventilation system in specific livestock buildings.

The technology of blockchain can secure storage of data and/or issuing reports in this system (Garg et al., 2021). Figure 1 presents a schematic diagram of the use of ESP8266 in a milk supply chain. The real-time data collected by the sensors at all production stages are transmitted to blockchain through the ESP8266 module. From the blockchain, an internet-connected mobile device can easily monitor the data.

Figure 2 shows the architecture of an environmental monitoring system using sensors and actuators for an efficient activation of ventilation and cooling systems of a livestock building. In this application, the ESP8266 module also transmits the collected data to the next stage of the system, storing and processing the data. The architecture consists of sensors to monitor environmental variables and a graphic interface that allows access and management of the application (Nugroho et al., 2016). For an easy and quick access to the collected data, the graphical interface can be incorporated in the system as proposed by Shuba et al. (2016).

Pereira et al. (2020) proposed a system of environmental data collection for a layer chicken house. The system consists of an ESP8266 module connected to a temperature and relative humidity sensor, an ammonia sensor and a light sensor. In this system, ESP8266 also favors real-time connectivity with the internet network. The module was used to carry out interventions in the system

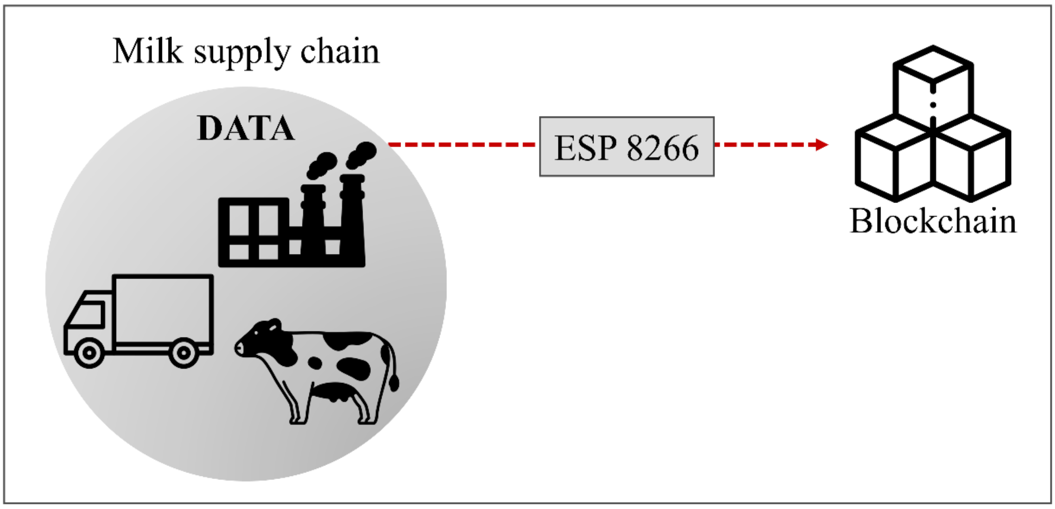

Figure 1. Schematic diagram of the blockchain technology with the ESP8266 module helping in the transmission of data in real time

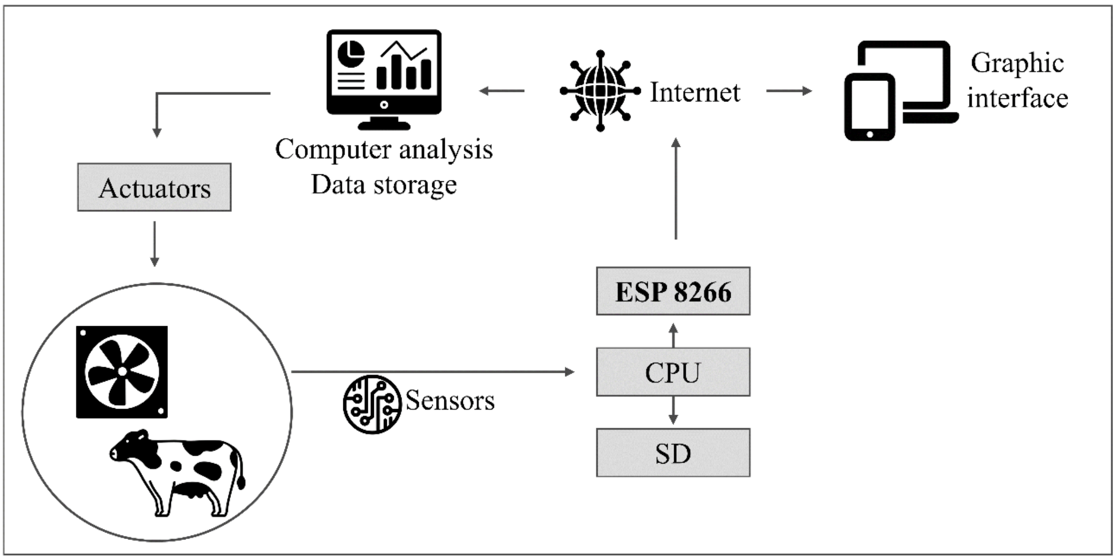

Figure 2. Architecture of the monitoring and control system equipped with sensors, actuators and the ESP8266 module

and correct malfunctions that may appear, ensuring that the environmental condition is suitable for laying birds.

Chigwada et al. (2022) developed a low-cost system for monitoring and controlling temperature and relative humidity, water supply, ammonia (NH_3) and light in egg production using the ESP8266 NodeMCU microcontroller. The system provided greater efficiency in the production process and animal productivity. Ruiz-Ortega et al. (2022) used the ESP8266 module and built a system for monitoring and analyzing weather conditions. The module connected to the Wi-Fi network sends real time data on temperature and air relative humidity, solar radiation and wind speed to a server.

The ESP8266 module can be effective in monitoring environmental conditions and automated greenhouses, grain drying and storage processes (Sindwani et al., 2020; Zhou et al., 2020). Furtado et al. (2022) connected ESP8266-12E to humidity and temperature sensors and a relay to create an automated system for drying cocoa beans. The authors reported that the system developed was able to collect data and activate the ventilation system in real time with a reduced response time. Sindwani et al. (2020) developed a system for monitoring and predicting the quality of stored grains using IoT and machine learning. In this study, they connected the ESP3266 module to a temperature and humidity sensor and a CO_2 sensor. The authors found good performances of the system in prediction and response time. In greenhouses, the ESP8266 can be connected to sensors and combined with relays for automation of ventilation and irrigation systems.

However, the use of IoT for monitoring and automating agricultural systems may be affected by Internet connectivity issues, mainly in the most remote regions. The internet communication network is not accessible to all farmers and can be unstable in certain regions and in adverse weather conditions. In order to bypass this limitation, Nugroho et al. (2016) created in a greenhouse a system to monitor and control irrigation and environmental conditions in a region with internet instability. The system developed operated in online and offline mode, using a local management subsystem, which worked with no connection to the internet/network, and a global management system, which operated in connection to the internet/network and performs data transmission. Thus, the system proposed was able to collect, store and analyze data, for subsequent management of the irrigation system.

CONCLUSION

- The ESP8266 module, among all its variants presented, can play an important role in animal production. It enables the transmission of collected environmental data so as they can be stored and/or processed. ESP8266 can integrate decision-making systems, as it can provide real-time data collected by the connected sensors.

AUTHORSHIP CONTRIBUTION STATEMENT

ZANETONI, H. H. R.: Conceptualization, Formal Analysis, Methodology, Writing – original draft, Writing – review & editing; **SOUZA, M. A.:** Conceptualization, Formal Analysis, Methodology, Writing – original draft; **PARANHOS, C. O.:** Conceptualization, Formal Analysis, Methodology, Writing – original draft; **QUEIROZ, D. M.:** Conceptualization, Methodology, Resources, Supervision, Writing – review & editing; **SOUSA, F. C.:** Supervision, Writing – review & editing.

DECLARATION OF INTERESTS

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

REFERENCES

Baêta, F., & Souza, C. (2010). **Ambiência em Edificações Rurais** (2º ed, Vol. 1). Editora UFV.

Becker, C. A., Collier, R. J., & Stone, A. E. (2020). Invited review: Physiological and behavioral effects of heat stress in dairy cows. **Journal of Dairy Science**, 103(8), 6751-6770.

Burhans, W. S., Rossiter Burhans, C. A., & Baumgard, L. H. (2022). Invited review: Lethal heat stress: The putative pathophysiology of a deadly disorder in dairy cattle. **Journal of Dairy Science**, 105(5), 3716-3735.

Ceja, J., Renteria, R., Ruelas, R., & Ochoa, G. (2017). Módulo ESP8266 y sus aplicaciones en el internet de las cosas. **Revista de Ingeniería Eléctrica**, 1(2), 24-36.

Chen, S., Yong, Y., & Ju, X. (2021). Effect of heat stress on growth and production performance of livestock and poultry: Mechanism to prevention. **Journal of Thermal Biology**, 99, 103019.

Chigwada, J., Mazunga, F., Nyamhere, C., Mazheke, V., & Taruvinga, N. (2022). Remote poultry management system for small to medium scale producers using IoT. **Scientific African,** 18, e01398.

Espressif Systems. (2022). **ESP8266EX Datasheet**. https://www.espressif.com/en/subscribe.

Furtado, W. V. dos S., Vaz Júnior, O. A., Veras, A. A. de O., de Sá, P. H. C. G., & Antunes, A. M. (2022). Low-cost automation for artificial drying of cocoa beans: A case study in the Amazon. **Drying Technology**, 40(1), 42-49.

Garg, L., & Kumar, K. (2021). Application of distributed ledger technology Blockchain in agriculture and allied sector: A review. **~ 215 ~ The Pharma Innovation Journal**, 2, 215-221.

Gonzalez-Rivas, P. A., Chauhan, S. S., Ha, M., Fegan, N., Dunshea, F. R., & Warner, R. D. (2020). Effects of heat stress on animal physiology, metabolism, and meat quality: A review. **Meat Science**, 162, 108025.

Hlaing, W., Thepphaeng, S., Nontaboot, V., Tangsunantham, N., Sangsuwan, T., & Pira, C. (2017). Implementation of WiFi-Based single phase smart meter for internet of things (IoT). 2017 **International Electrical Engineering Congress, iEECON 2017**.

Hoffmann, G., Herbut, P., Pinto, S., Heinicke, J., Kuhla, B., & Amon, T. (2020). Animal-related, non-invasive indicators for determining heat stress in dairy cows. **Biosystems Engineering**, 199, 83-96.

Kumar Sai, K. B., Mukherjee, S., & Parveen Sultana, H. (2019). Low Cost IoT Based Air Quality Monitoring Setup Using Arduino and MQ Series Sensors With Dataset Analysis. **Procedia Computer Science**, 165, 322-327.

Michie, C., Andonovic, I., Davison, C., Hamilton, A., Tachtatzis, C., Jonsson, N., Duthie, C.-A., Bowen, J., & Gilroy, M. (2020). The Internet of Things enhancing animal welfare and farm operational efficiency. **Journal of Dairy Research**, 87(S1), 20-27.

Nugroho, A. P., Okayasu, T., Hoshi, T., Inoue, E., Hirai, Y., Mitsuoka, M., & Sutiarso, L. (2016). Development of a remote environmental monitoring and control framework for tropical horticulture and verification of its validity under unstable network connection in rural area. **Computers and Electronics in Agriculture**, 124, 325-339.

Pereira, W. F., Fonseca, L. da S., Putti, F. F., Góes, B. C., & Naves, L. de P. (2020). Environmental monitoring in a poultry farm using an instrument developed with the internet of things concept. **Computers and Electronics in Agriculture**, 170, 105257.

Polsky, L., & von Keyserlingk, M. A. G. (2017). Invited review: Effects of heat stress on dairy cattle welfare. **Journal of Dairy Science**, 100(11), 8645-8657.

Rawlins, B., Trevathan, J., & Sattar, A. (2022). Embedded fog models for remote aquatic environmental monitoring. **Internet of Things**, 20, 100621.

Roth, Z. (2020). Reproductive physiology and endocrinology responses of cows exposed to environmental heat stress - Experiences from the past and lessons for the present. **Theriogenology**, 155, 150-156.

Ruiz-Ortega, J., Martínez-Rebollar, A., Flores-Prieto, J., & Estrada-Esquivel, H. (2022). Design on a Low Cost IoT Architecture for Greenhouses Monitoring. **Computación y Sistemas**, 26(1), 221-232.

Shuba, A., Le, A., Alimpertis, E., Gjoka, M., & Markopoulou, A. (2016). **AntMonitor: A System for On-Device Mobile Network Monitoring and its Applications.**

Sindwani, A., Kumar, A., Gautam, C., Purohit, G., & Tanwar, P. (2020). Prediction and Monitoring of stored food grains health using IoT Enable Nodes. **2020 IEEE International Conference on Computing, Power and Communication Technologies (GUCON),** 516-522.

St-Pierre, N. R., Cobanov, B., & Schnitkey, G. (2003). Economic Losses from Heat Stress by US Livestock Industries. **Journal of Dairy Science**, 86(SUPPL. 1), E52-E77.

Thomazini, D., & Albuquerque, P. U. B. de. (2020). **Sensores industriais: fundamentos e aplicações**. (Saraiva Educação SA).

Tong, X., Hong, S.-W., & Zhao, L. (2019). CFD modelling of airflow pattern and thermal environment in a commercial manure-belt layer house with tunnel ventilation. **Biosystems Engineering**, *178*, 275-293.

Zhou, L., Qiu, Z., & He, Y. (2020). Application of WeChat Mini-Program and Wi-Fi SoC in Agricultural IoT: A Low-Cost Greenhouse Monitoring System. **Transactions of the ASABE**, 63(2), 325-337.