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IoT-Based pH monitoring for detection of rumen acidosis

[*Monitoramento de pH com base em IoT para detecção de acidose ruminal*]

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ABSTRACT

Rumen acidosis is a fatal disease that reduces milk and pregnancy yield due to digestion of cattle and when not detected. Diagnosis of this disease can be achieved by monitoring the nutritional parameters of the cattle. Internet of Things (IoT) technology is a technology used in these kinds of processes such as monitoring and tracking within the scope of Industry 4.0. Thanks to the IoT, data collection, analysis, and data processing stages are carried out instantly over the internet. In this research, an IoT-based system has been developed that can be effective in diagnosing acute rumen acidosis disease in cattle and monitoring the control of data by recording nutritional parameters. Rumen pH and temperature values were measured with an IoT-supported microcontroller, and the data were recorded in the database on the server using. The circuit and software were first tested in the laboratory environment and then in the rumen of the cannulated cattle. The pH and temperature values of rumen were measured and recorded instantaneously at certain intervals (when the animal was ruminating, after drinks water, after eating dry food, and while at rest). When the device is removed from the rumen, it has been observed that the PLA-type plastic material used in the coating of the circuit does not wear. The device was useful in the early detection of acidosis disease of an animal fed with dry feed for more than 2 hours before it turns into epilepsy and provided early intervention in the regulation of the ration.

Keywords: acidosis, internet of things (IoT), monitoring, pH, real-time, rumen

RESUMO

A acidose ruminal é uma doença fatal que reduz a produção de leite e a gravidez devido à digestão do gado e quando não é detectada. O diagnóstico desta doença pode ser alcançado através do monitoramento dos parâmetros nutricionais do gado. A tecnologia Internet das Coisas (IoT) é uma tecnologia usada neste tipo de processo, como monitoramento e rastreamento dentro do escopo da Indústria 4.0. Graças ao IoT, a coleta de dados, análise e etapas de processamento de dados são realizadas instantaneamente pela Internet. Nesta pesquisa, foi desenvolvido um sistema baseado em IoT que pode ser eficaz no diagnóstico da acidose ruminal aguda no gado e no monitoramento do controle de dados através do registro de parâmetros nutricionais. Os valores de pH e temperatura do rúmen foram medidos com um microcontrolador suportado por IoT, e os dados foram registrados no banco de dados no servidor usando. O circuito e o software foram testados primeiro no ambiente de laboratório e depois no rúmen do gado canulado. Os valores de pH e temperatura do rúmen foram medidos e registrados instantaneamente em certos intervalos (quando o animal estava ruminando, depois de beber água, depois de comer comida seca e enquanto estava em repouso). Quando o dispositivo é removido do rúmen, foi observado que o material plástico do tipo PLA usado no revestimento do circuito não se desgastou. O dispositivo foi útil na detecção precoce da doença de acidose de um animal alimentado com ração seca por mais de 2 horas antes de se transformar em epilepsia e forneceu intervenção precoce na regulação da ração.

Palavras-chave: acidose, internet das coisas (IoT), monitoramento, pH, tempo real, rúmen

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INTRODUCTION

Acute rumen acidosis is one of the digestive diseases seen in ruminants. Acidosis is often based on the time of occurrence of what you find in the classification of acute and subacute, clinics can be observed. According to it, it is divided into two as clinical or subclinical. In acute rumen acidosis disease immediately following consumption of fast-fermenting carbohydrates they show that they are present (Nagaraja and Titgemeyer, 2007). Since there are many types of diseases in cattle, the disease groups and main disease types are as follows and shown in Table 1.

Table 1. Disease groups and types of diseases (Kaya, 2019)

Disease Groups	Disease Types
Obstetrics	Mastitis, Metritis, Infertility, Pyometra
Digestive System Diseases	RPT, Abomasum displacements, Food indigestions, Asidozis
Surgical Diseases	Arthritis, difficult births, and cesarean sections
Respiratory Diseases	Pneumonie, Tastorollosiz, Pleuropneumonia
Metabolic Diseases	Ketosis, Hypocdsemia
Blood Diseases	Theileia, Anaplasma
Circulatory Diseases	Cardiovascular Disorders, Anaphylactic Shock
Nervous System Diseases	Botilismus, Listerioriss, Metal poisoning
Urinary Diseases	Nephritis, Leptospirosis
Zoonotic	Anthrax, Rabies
Skin Diseases	Scabies, External parasites

One of the most important problems of dairy cattle breeding is metabolic diseases are coming. As is known, the main nutritional diseases in dairy cattle are fever, breast edema, ketosis, fatty liver syndrome, retention placenta, abomasum displacement is rumen acidosis (acute and subacute), and laminitis. Subacute rumen acidosis (SARA) is an important disease for our country (Gülmez, 2007). The development of livestock breeds over time is an important factor in the increase in the daily use of both mixed feed and roughage in farm animals. One of the causes of acidosis is eating too many carbohydrates in the ration. After consuming many carbohydrates, the acid level in the rumen pH increases. Rumen pH varies depending on the type, amount, digestion rate, and activity of the animal consumed during the day. Acute clinical or lactic acidosis (grain overload, grain poisoning, acute indigestion) ruminal without feed adaptation in cattle, sheep, and goats.

Excessive feeding of high fermentable, carbohydrate-rich feeds (Crichlow and Chaplin, 1985). Highly EFA (Essential Fatty Acids) and lactic acid production increase rumen pH beyond physiological limits. In time, the buffering capacity of the rumen decreases, the efficiency of the rumen flora fermentation ability decreases. Acute acidosis: rumenitis, metabolic acidosis, it can cause lameness, liver abscess, pneumonia, and death (Lean and Wade, 2000). The material of Table 2 was made on 25,592 dairy cows by TARSIM (Agricultural Comprehensive Cattle Life Insurance offered by the Insurance Pool) throughout Turkey in 2015.

Table 2. According to the causes of death of dairy cattle with 2015 TARSIM insurance

Distribution	Death Cause Number of Deaths
Obstetrics	6,375
Digestive System Diseases	5,418
Surgical Diseases	5,013
Respiratory Diseases	2,643
Metabolic Diseases	640
Blood Diseases	420
Circulatory Diseases	298
Nervous System Diseases	238
Urinary Diseases	103
Zoonotic	52
Skin Diseases	41
Other	31
Total	21,272

Table 2 according to the causes of death of dairy cattle with 2015 TARSIM insurance show the distribution. From Table 2, among the causes of death, the second-highest number of deaths is caused by Digestive System Diseases with 5.418 and the least cause of death is 41 it seems to be caused by menstruation and skin diseases. It is seen that the total number of deaths due to digestive Lsystem disorders is 25.4%.

Rumen acidosis (low pH value) is a very common disturbance and occurs indigestion based on microorganisms associated with incoming disorders. Acidosis: fermented quickly and easily the ingestion of carbohydrates and/or the environment of the rumen organic acids after their protective capacities are weakened is a result of the abnormal increase. Fever measured from the rectum was normal at first, then normal can go under. Beef shakes like a drunk (paresis), eyes run in (enophthalmos), and skin may become slightly cold. Difficulty standing up and symptoms are aggravated with a serious loss of fluid. The animal sometimes dies within a few hours (sudden death), sometimes several dies after the day. There are many complications with the disease, such as Rumenitis: Appetite decreases, animal weakens, belly collapses into it, the cow's condition does not improve; Acute stiffness: In the most severe cases, the cow lies on the ground, feet sideways correctly stretched or stepped while walking, and when it stops, it just stays; Enterotoxemia: disease progression, pathogen Clostridium intestinal poisoning and infection caused by bacteria the result is punctuated by sudden death (Anne-Marie Paulais *et al*., 2011). The frequency and strength of rumen movements with a fall in rumen pH ruminal atony occur around pH 5.00. Most researchers define acidosis as the condition of rumen pH below 5.50. SARA for a day as the rumen pH remained below 5.50 for more than 174 minutes in the process they have defined (Plaizier *et al*., 2008).

The ability of the rumen to perform its duties correctly is directly related to pH (Öztürk and Pişkin, 2009). The stomach structure of ruminant animals is different from other monogastric animals. The structure of the stomach in monogastric organisms is simple and enzymatic. İn ruminants, this structure is divided into four parts as the rumen, reticulum, abomasum, and omasum [9]. shows the stomach structure of cattle. Measuring and noting the pH level in the rumen section is important for animal and herd health. İn addition, observing and recording body temperature should be considered as an important parameter in the determination of acidosis.

As the world's population grows, its nutritional needs continue to increase dramatically, so it is impossible for agriculture, an important part of the national economy, to remain so (Özel and Sariçiçek, 2009). The internet of things (IoT) is an application area integrated into social and daily life, where different technologies are developed and used. İn other words, the IoT helps to make sense of the movements of people, animals, vehicles, air currents and among themselves and within themselves under the same conditions. What makes IoT so important and vital is that it connects and provides access to physically sourced products and items, both to each other and to digitally sourced appliances such as computers and software applications. Sensor systems that continuously monitor the physiological conditions of the animal are important for maximizing animal welfare and optimizing farm productivity (Davison *et al*., 2020). This allows instant data sharing for all these devices, via group or multi-point principles and cloud computing. In this study, a system has been developed to be used in the diagnosis of acidosis in cattle rumen without causing death by using IoT technology. The device records the pH and temperature data from the rumen of the animal and saves it to the server. The outer coating of the device was tested in rumen fluid in the laboratory environment before it was placed in the rumen region.

With the development of the Internet of Things technology, Industry 4.0 has become a necessity for observing and processing big data in almost every area of life. It is seen that the follow-up and monitoring processes are increasing rapidly in the livestock field. In addition to scientific research, there are systems developed to monitor and control the health status and milk yield of cattle. Most of the work on agricultural IoT systems is seen in countries with higher levels of economic development (Bamurigire *et al*., 2020). In these studies, various types of pH sensors have been developed for rumen measurements in cattle (Zhang *et al*., 2016a). İmmediate monitoring of the rumen is made possible by an extremely-high-precision, solid-type pH sensor with extremely low power consumption for each measurement (Zhang *et al*., 2016b). A solid-type pH sensor has been developed to measure the rumen pH of dairy cattle. This pH sensor is adapted to determine the daily pH range of the rumen. İt has been understood that this developed sensor helps to monitor the health status of the animals in a healthy way (Zhang *et al*., 2016c). It has been determined that the use of some advanced pH sensors is necessary for the prevention of acidosis and increasing the efficiency of its production (Zhang *et al*., 2016). It has been noted that the pH sensor has had a stable performance for a long time (Zhang *et al*., 2017). Birth accidents and offspring adoption have been monitored experimentally using IoT. Afterward, the ration was determined according to the weight of the pigs and the CO2 and humidity levels in the environment were observed (Zhang *et al*., 2018). Data were collected and analyzed by using IoT and RFID technologies to describe farm animals (Huang *et al*., 2015). IoT reveals the need for the development of a new system that could theoretically be more efficient and suitable in animal habitat research and some studies (Songtao *et al*., 2015). RFID carrier chips determined by ear numbers were attached to cattle to identify their identities (Erdem, 2007). The animals' body temperature was measured in detail and their behavior was monitored (Mayer *et al*., 2004). IoT technologies are used to measure and determine the temperature, humidity, light intensity, wind speed, and some gas parameters in the environment of poultry as well as farm and livestock animals (Jianhua *et al*., 2016). The pH level of gastric juice was determined by measuring the pH level of the gastric juice with a pH meter placed in the stomach of dairy cows (Mottram *et al*., 2008). The findings, which emerged because of collecting and processing the data on the disease symptoms of the cattle by means of sensors were sent to the veterinarian. These submitted findings have been shown to assist veterinarians in diagnosing cattle disease (Yanığlı *et al*., 2015). A web-based storage system has been developed by collecting data from multiple sensors about the position, viewing areas, neck movements of pasture animals (Debauche *et al*., 2017). In dairy cows, a system has been developed in which the body temperature, sound volume, and neck movements of the animal are detected and measured with the help of smart collars (Awasthi *et al*., 2016). The importance of monitoring the pH in the rumen section for the early diagnosis of acidosis has been demonstrated (Lalu *et al*., 2015). Efforts are being made to develop an IoT-based pH value control system that provides instant information (Santoso *et al*., 2017). An example of a study where a bolus containing a mote (temperature sensor, processor, and radio) is inserted into the rumen of the cow to monitor body temperature (Ipema *et al*., 2008). The water quality is continuously monitored with the help of sensors (PH, Temperature, Turbidity, conductivity, water level indicator) (Kumar *et al*., 2021). The obtained data is sent to the cloud by using IoT based ThinkSpeak application to monitor the quality of the water (Satish *et al*., 2020). An example showing the various sensors, challenges, advantages, and disadvantages hat help IoT and agriculture (Sanika *et al*., 2020). It proposes an IoT-based model to prevent potential damage to agriculture from both wild animals and weather conditions (Alimul *et al*., 2021). An example of IoT-based ThinkSpeak used in agriculture (Nanda *et al*., 2021). An example of an improved multilayer perceptron approach for detecting sugarcane yield production in IoT-based smart agriculture (Pengwen *et al*., 2021). An example that could enable the Internet of Things (IoT) system development and the application of data analytics to improve agricultural production security (Chappidi and Srinivasa., 2021). A study of LoRaWAN protocol performance for IoT applications in smart agriculture (Badreddine *et al*., 2020). Application of agricultural IoT technology based on 5G network and FPGA (Xianhai, 2021). A smart agriculture IoT system based on deep reinforcement learning (Fanyu and Xin, 2019). A research case within the Framework for Optimizing IoT Deployment for the Precision Agriculture Industry (Abdellah *et al*., 2020). Evolution of Internet of Things (IoT) and its significant impact in the field of Precision Agriculture (Abhishek *et al*., 2019). An automated low-cost IoT-based Fertilizer Intimation System for smart agriculture (Lavanya *et al*., 2020).

MATERIALS AND METHODS

In this study, a system was developed for the diagnosis of acidosis disease in the rumen part of cattle by using IoT. This designed system consists of two parts, hardware and original software that reads the data from the sensors in the hardware. The developed device was calibrated in solution liquids with a pH value of

4.0 and 7.0 in laboratory practice. After calibration, pH and temperature values were monitored simultaneously from the system every 15 minutes. The system was tested in a laboratory environment and the data was analyzed. Values of pH close to the rumen fluid were prepared as a solution and the device was kept in this liquid. The materials used in the device have been developed and designed in such a way that they can be placed in the rumen part of the animal without any problems and have been adapted in accordance with the tests.

The pH (power of hydrogen) sensor is used to determine and observe the acidic or basic values of the measured liquid. pH is the term that indicates the degree of acidity or alkalinity of a solution. This degree is measured at a value between 0-14. The pH of the measured pure water is 7 in value. A solution’s pH close to 0 indicates it is acidic and close to 14 it is basic. Figure 1 shows a pH sensor.

Figure 1. pH sensor.

It is a new version of the DS18B20 sensor with a wired and waterproof feature. This waterproof is used when it comes to intra-rumen settings. It is a useful device when it is necessary to measure a condition in remote, damp situations. The sensor can work +125°C, the cable is covered with PVC, it is recommended to keep the sensor below 100°C. Since they are digital even over long distances, there is no signal degradation. These wired digital temperature sensors used have very precise sensitivity (±0.5°C for most of the range) and can provide high precision up to 12-bits from the built-in digital-to-analog converter. It can be used with 3.0-5.0V systems. A waterproof temperature sensor is shown in Figure 2.

Figure 2. waterproof temperature sensor (DS18B20)

ESP8266EX based Wemos D1 mini microcontroller, which supports WiFi 802.11 b/g/n standards, is used in the study. This microcontroller, which is preferred due to its small structure and used in the IoT circuit, has been preferred because it is applicable to the rumen region of the livestock. The specifications of this microcontroller are given in Table 3.

Table 3. Wemos d1 mini technical features

Definition	Features
Number of in/out pin	11 pieces (1 analog input)
Connection	Micro USB
Power inlet support voltage	9-24 V
Voltage	3.3 V
Memory	4 MB
Weight	25 gr

Thanks to the deep sleep mode, after the data is transmitted, the microcontroller is put into sleep mode, minimizing power consumption. The pin information and appearance of the module are given in Figure 3.

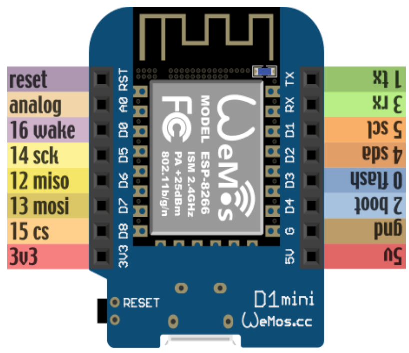


Figure 3. Wemos d1 mini microcontroller.

The supply unit used in this study has the power to handle high amperes for microcontrollers and electronic devices, but 30 amps of current can be drawn from these batteries (Charine *et al*., 2018). New processes were made to stabilize the microcontroller and pH sensor kit. The characteristics of the selected battery are shown in Table 4.

Table 4. Sony vtc6 18650 battery technical features

Definition	Technical Features
Chemistry	Li-ion battery, lithium-ion battery
Voltage	3.7 V
Capacity	3000 mAh
Instant discharge	30 Ampere
Weight	48.50 gr
Sizes	18.25

The material required for coating the circuit is covered with a 3D printer. Most used in 3D printers, one of the thermoplastics is polylactic acid (PLA). PLA is biocompatible and biodegradable and it is emerging with its low price and food packaging industry, the most preferred in the biomedical industry is thermoplastics (Kaygusuz and Özerinç, 2019). The circuit is placed in a waterproof unit. The general view of the material on which the system is coated is shown in Figure 5.

Selçuk University application farm was chosen as the application environment of the circuit. Cannula, by its broadest definition, are called tubes that are opened in the body of any animal (human, cow, cat, dog, etc.) or inserted through an existing channel. Figure 6 shows cannulated cattle and Figure 7 shows the farm environment.

Figure 5. The appearance of the material on which the circuit is covered.

The circuit measures the pH value analogously with the pH sensor and the temperature value digitally with the waterproof sensor. The circuit was placed in the rumen by covering it with durable material. pH and temperature values were monitored instantaneously wirelessly. The received data is read with the help of a microcontroller. The data received from the pH sensor is converted to mv (millivolt) values by the software in the microcontroller. After the data is read, it is transferred directly to the webserver using the internet communication protocol. An overview of the system is shown in Figure 8. The data collected on the server is saved in the database. The data is transferred to the server via the microcontroller in three blocks: mac address, pH value, and temperature value. The MAC address of the sent IoT device is matched to the animal ID number in the software. These recorded pH and temperature data are displayed graphically in the software.

Figure 6. Cannulated cattle.

Figure 7. The farm environment.

When the microcontroller is energized, it tries to connect to the existing wi-fi network. After the connection is successful, the device's IP address and stable mac address on DHCP are printed on the screen. The device measures pH and temperature. It saves all these four data in the database in the software part. The IP address and mac address submitted in the database are matched to an ID and fixed with the animal's earring number and name.

After the microcontroller is started, it measures the analog data and sends the IP address and measured data to the software. The data is checked, and it goes into 15 minutes sleep mode. In Figure 10, the processing cycle of the software running in the microcontroller is given. Data sent from the microcontroller to software and its types are shown in Figure 11.

The pH sensor is a sensor that gives an analog output. There are also sensors on the market that provide digital output, but since the part requiring signal processing was made by the producer and the margin of error could not be seen, an analog output pH sensor was used. An amplifier circuit was designed for 0-14 pH values to detect too low voltage variations of the analog output. The phototransistor sensor, called CNY70, was used for testing the amplifier circuit and a sine wave was given. At the end of the test, a square wave with equal frequency and different output values were obtained for different pH values.

Wemos D1 Mini model microprocessor development card was used because of its small size and Wi-Fi connection. The power supply of the circuit is a non-regulated 18650 VTC 6 model battery. Battery life is 2 months. Analog pH sensor and waterproof temperature sensor are connected to the microcontroller on the device. The power supply of the device was provided by a 3.7-volt lithium battery. This value was based on the amount of current consumed by the circuit during the simulation. The circuit at which the measurements were made is shown in Figure 12.

The logic of function is to convert an analog signal to digital by the analog-to-digital module and a window form application has been developed to monitor this value from any communication device in the same network through the IP address. The wiring diagram of the circuit where the measurements are made is shown in Figure 13.

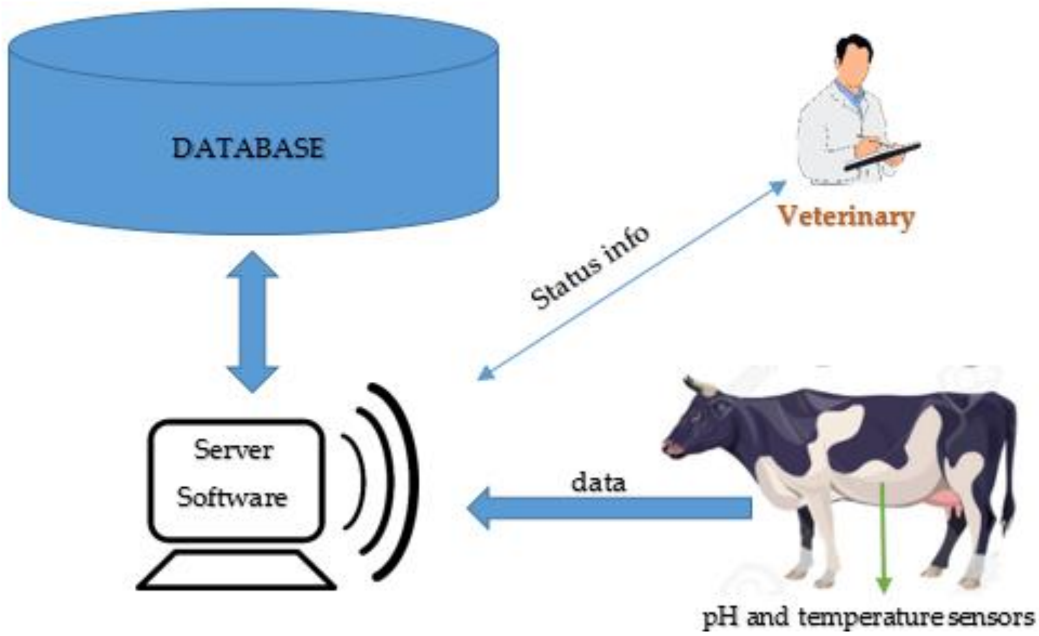


Figure 8. Overview of the system.

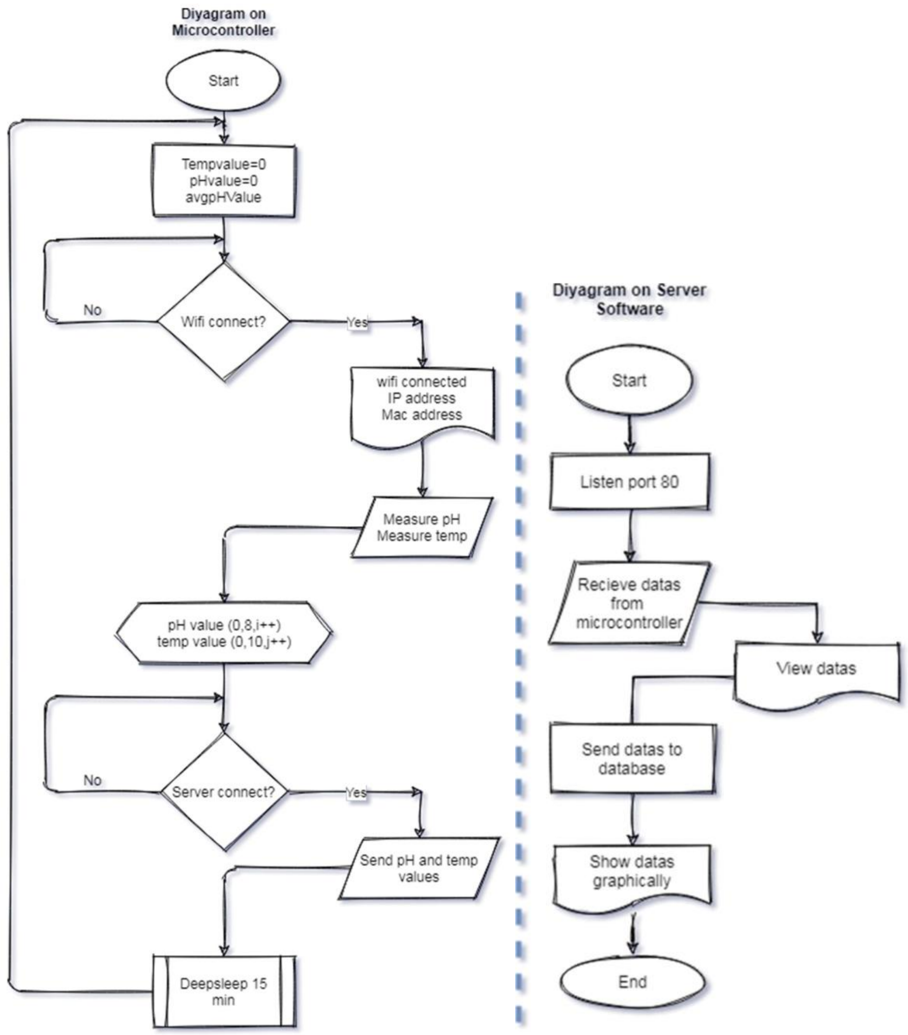


Figure 9. (a) Diagram of the software run on the side of the microcontroller; (b) Diagram of the software run on the side of the server.

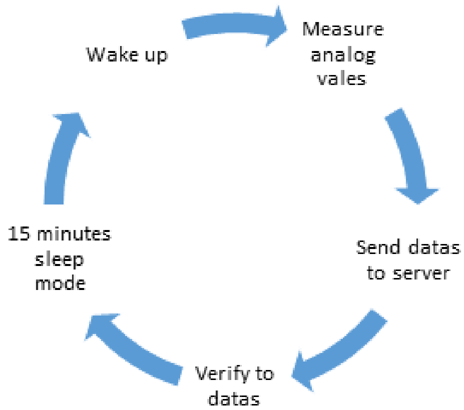


Figure 10. Processing cycle on the side of microcontroller.

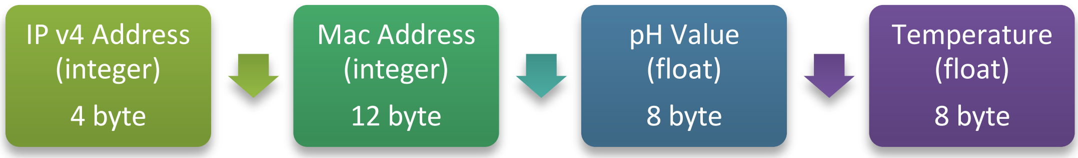


Figure 11. Data and types.


Figure 12. Overview of device.

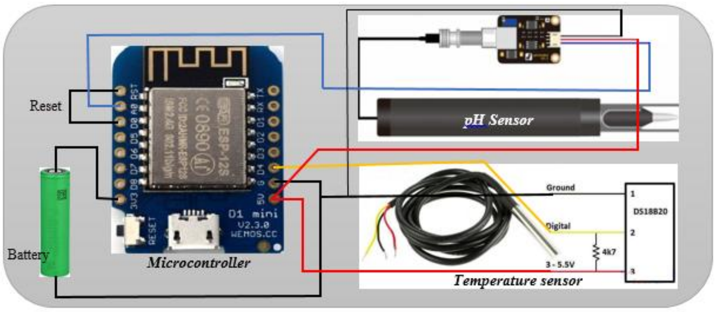


Figure 13. General connections of the device.

It was designed to be suitable for the integrated system design with a cloud system by adding data records so that real-time and retrospective data analysis would be made.

There are 4 types of users and authorizations in the software. These are named root, vet, technician, and user. With the authority of the administrator, a new farm and users of this farm can add, delete, and authorize the system. The user with veterinary authority can enter, add, delete, and edit all kinds of data belonging to the farm he belongs to. The user authorized by the technician can enter limited data about the farm he belongs to. Authorized persons in the username are only authorized to see and read the information. In Figure 14, usernames and authorizations in the system are shown.

Figure 14. Users and authorizations.

The microcontroller transmits the measured data to the server via web protocol. On the server-side, this data is processed and analyzed graphically. Figure 15 shows the first interface of the software. Measured values outside the lower and upper limits of the incoming data in this interface are filtered in the alarm system section and displayed to the user.

An IoT device can send more than one sensor data at the same time, or it can send only one. There is no restriction. Multiple IoT devices can be connected to an animal more than one IoT device transmitting the same sensor data can be connected. For example, 2 separate IoT devices transmitting temperature data can be connected to an animal. If the IoT device is deleted, the instant sensor data from that device will not be kept by the system. When mapping between the Earring No and IoT Mac Address, it must be mapped to the correct Earring No.

In the system interface: Dashboard, Alarm system, Animal Management, Milk tracking management, Supplier management, Health follow-up management, IoT management, Sensor management sections are available.

General information is shown to users in the Dashboard section. In this information the number of animals on the farm, daily and total milk collected and sold are reported. In the animal management part, a new animal can be added to the selected farm by birth or sale. It also offers the ability to delete, edit and list animals. In the milk tracking management section, the amount of milk milked from the selected animal daily, the milking time, and the information by whom this process was performed is entered. In the supplier management section, the processes of adding, deleting, and editing the organizations that supply animals and milk to the farm or the suppliers that purchase the milk produced on the farm are performed. In the health monitoring section, it is possible to add, delete and list the vaccination information that can be applied to the animals. In addition, the health interventions applied to the animal and by whom it was made are recorded.

In the sensor management part, the sensors in the IoT device attached to the animal are defined to the system. The lower and upper limits of these defined sensors are determined. In addition, sensor addition, deletion, and listing operations are performed in this section.

While coding IoT devices; it needs sensor names during sending the received sensor data to the Server with HTTP REQUEST (GET, POST) operations. These names are defined here. In this way, the server recognizes the incoming sensor. Sensor names that IoT devices will send to API are predefined to the system. In this way, the automation system saves the data from the relevant sensor name to the system. There must be only one of the same sensor names. All IoT devices can use the sensor names here. It ignores sensor data with names not defined here. If data is sent to the undefined sensor name, the system ignores the incoming data. Since IoT devices send data 7/24 continuously, if sensor names are deleted and the relevant sensor name is not updated in IoT devices; since the sensor name is not registered in the system, the IoT ignores the sensor data sent by the device. If a sensor is deleted from the system; the data sent by the IoT device is not recorded by the automation.

In the IoT management part, the device inserted into the animal is defined. The mac address of this IoT device is matched with the earring number of the animal. In addition, adding, deleting, and listing a new IoT device to the system is done in this section.

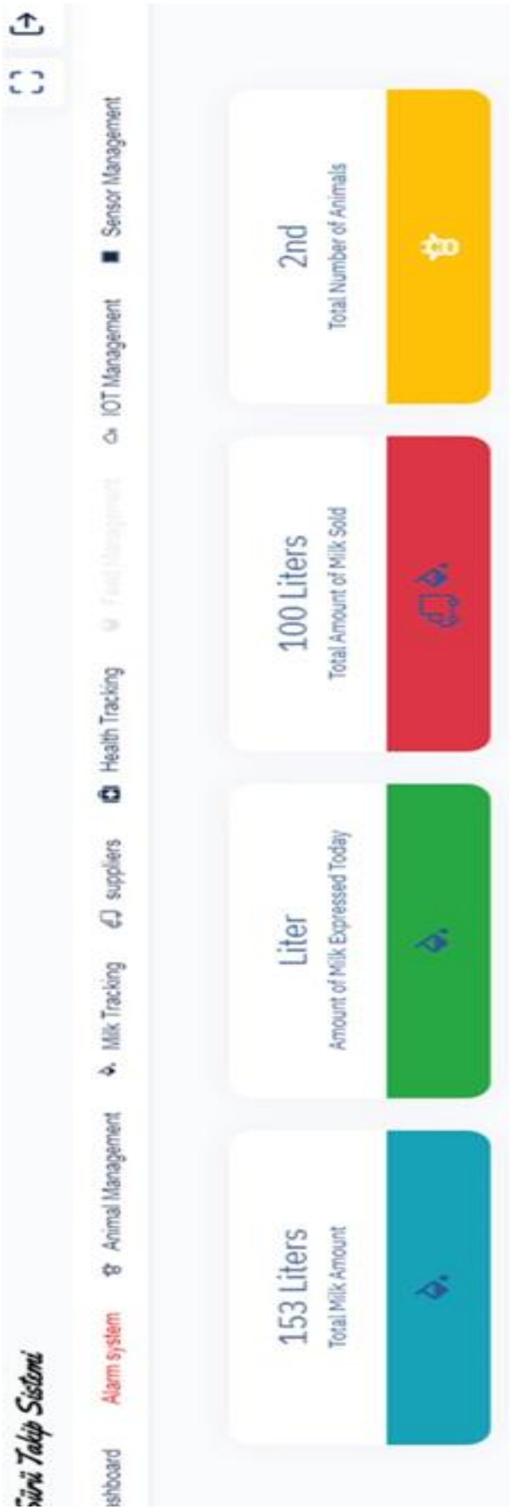


Figure 15. The first interface shows all data.

Many animals can be included in the system by matching MAC addresses without any numerical limitation. It is possible to give a separate identity for each animal by using the MAC address and IP information. This match is made to the earring numbers of the animals and is included in the system.

In the alarm system part, an upper limit, and a lower limit of the received data are determined when adding a sensor to the system. Data outside these limits, which animal it belongs to, and what date it is being listed. Figure 16 shows the time graph drawn on the program side.

General information about the animal is kept in the animal management section of the software. In the database section, the MAC address of the device to be integrated into the animal is matched with an ID and fixed. The microcontroller on the animal has IP address and mac address information. General information about this animal is shown in Figure 17.

The circuit covered with the 3D printer material is in such a way that it will not be damaged by the factors in the rumen, it will not be waterproof, and will not be irritated by the acidic environment. The polylactic material used in the coating of the circuit was found to be resistant to the bacterial environment in the rumen. Also, the thickness has been adjusted to keep the losses in the wi-fi signals used while sending the data to a minimum. The inside of the circuit covered with PLA by 3d printer is supported with foam material. The unit that is placed in the material designed in the 3D printer and sends the pH-temperature values to the server is shown in Figure 18.

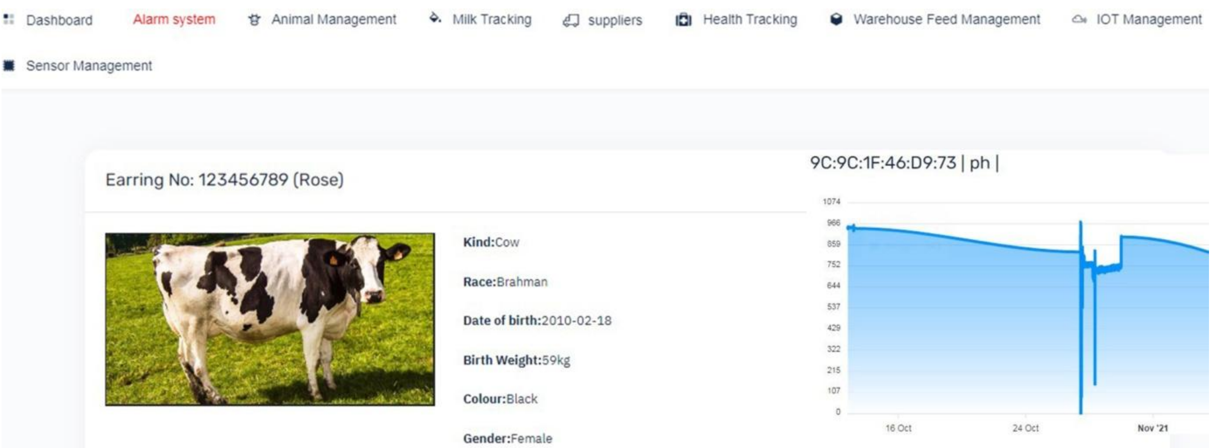
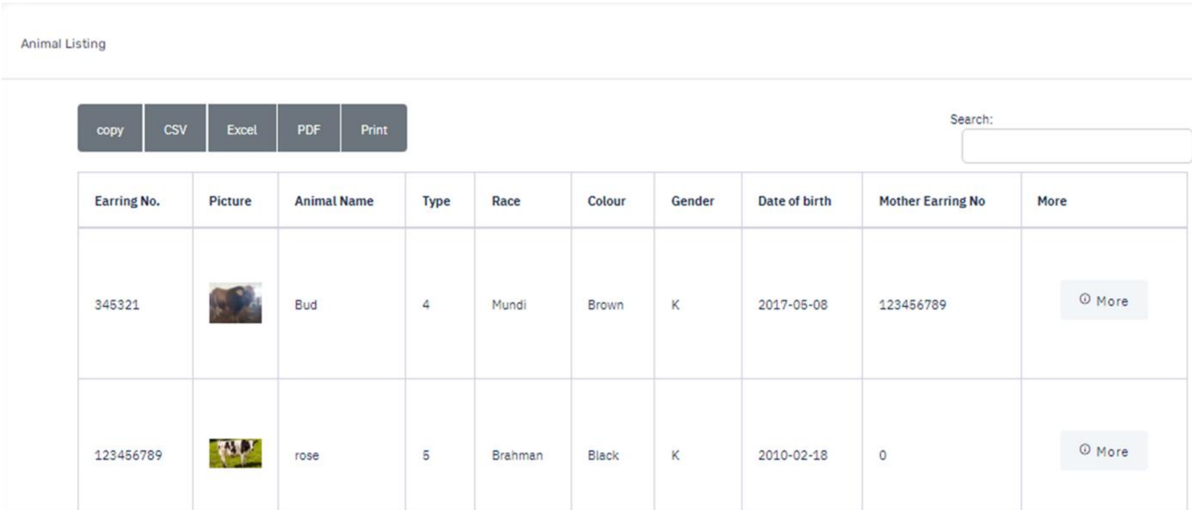


Figure 16. Sensor data - Time graph.


Animal Listing

copy CSV Excel PDF Print

Search:

Earring No.	Picture	Animal Name	Type	Race	Colour	Gender	Date of birth	Mother Earring No	More
345321		Bud	4	Mundi	Brown	K	2017-05-08	123456789	More
123456789		rose	5	Brahman	Black	K	2010-02-18	0	More

Figure 17. The table where animal information is kept.


Figure 18. Coated unit.

DISCUSSION

With IoT technologies it is easier to receive and process data in different areas and environments with the help of sensors. Dairy farms are growing in various parts of the world and need modernization (Chiumenti *et al*., 2020). Using the IoT-supported microcontroller, the rumen environment of a bovine animal and the pH and temperature values of the liquid taken from this rumen were transferred to the server wirelessly. The importance of antenna distance is very important in receiving data wirelessly. Table 5 shows the pH of the fluid taken from the rumen at laboratory temperature with the antenna distance. According to Table 5 data, it was observed that the calibration of the device worked stably without antenna distance.

The measured values of the environment were observed with pH and temperature sensors. The circuit was kept in the rumen region of a bovine for 8 hours and the values read every 15 minutes were recorded wirelessly. The rumen temperature and pH values are shown in Table 6 when the cow is ruminating, in Table 7 after when the cow drinks water, in Table 8 after the cow after eating dry food, in Table 9 when the cow resting.

The average temperature and pH values for 8 hours every 15 minutes in the measured period are shown in Table 10.

Table 5. pH solution at laboratory temperature is required

Antenna Distance	Temp. Value	Solution pH Value	Measured pH Value	Error Margin
5 m – 50m	23°C	6.80	7.02	0.22
5 m – 50m	24°C	6.90	7.02	0.22
5 m – 50m	25°C	6.95	7.02	0.22
5 m – 50m	26°C	6.98	7.02	0.22

Table 6. pH and temp values when the cow is ruminating

Date and Time	Temp Values	pH Values
2021-03-12 12:00:34	39.5	6.91
2021-03-12 12:15:44	39.5	6.91
2021-03-12 12:30:35	39.6	6.9
2021-03-12 12:45:34	39.6	6.84
2021-03-12 13:00:53	39.5	6.85
2021-03-12 13:15:55	39.6	6.92
2021-03-12 13:30:56	39.6	6.98
2021-03-12 13:45:23	39.5	6.96

Table 7. pH and temperature values after the cow drink water

Date and Time	Temp Values	pH Values
2021-03-12 14:00:13	39.2	6.24
2021-03-12 14:15:17	38.8	6.35
2021-03-12 14:30:31	38.6	6.36
2021-03-12 14:45:14	38.2	6.14
2021-03-12 15:00:27	38.3	5.93
2021-03-12 15:15:47	38.4	5.91
2021-03-12 15:30:11	38.0	6.19
2021-03-12 15:45:40	38.4	6.21

Table 8. pH and temperature values cow after eating dry food

Date and Time	Temp Values	pH Values
2021-03-12 16:00:25	38.9	5.39
2021-03-12 16:15:49	39.7	5.41
2021-03-12 16:30:56	39.9	5.75
2021-03-12 16:45:23	40.6	5.84
2021-03-12 17:00:17	40.9	5.27
2021-03-12 17:15:31	40.6	5.31
2021-03-12 17:30:14	40.6	5.30
2021-03-12 17:45:27	40.8	5.22

Table 9. pH and temperature values after the cow while at rest

Date and Time	Temp Values	pH Values
2021-03-12 18:00:47	39.8	7.15
2021-03-12 18:15:11	39.6	6.82
2021-03-12 18:30:40	39.7	6.74
2021-03-12 18:45:25	39.8	6.73
2021-03-12 19:00:49	39.6	6.71
2021-03-12 19:15:34	39.6	6.79
2021-03-12 19:30:47	39.8	6.71
2021-03-12 19:45:05	39.9	6.72

Table 10. 8-hour average values of four stages

Situation	Average temp	Average pH
Table 4 (when the cow is ruminating)	39.55	6.90
Table 5 (after the cow drinks water)	38.48	6.16
Table 6 (cow after eating dry food)	40.25	5.43
Table 7 (cow while at rest)	39.72	6.79

In rumen temperature varies between 39°C and 41°C (Church, 1984), pH varies between 5.5 and 7.0 (Murphy *et al*., 1982). It is aimed to assist in the diagnosis of acidosis which is one of the digestive disorders that will occur in the rumen regions because of the rations of bovine animals. The treatment process can be accelerated and financially advantageous by measuring the pH and temperature instantly and recording the information in the database.

It was observed that the pH level in the rumen approached the risky level for acute acidosis after feeding with dry food in the experimental animal whose pH and temperature values were monitored. By seeing the situation on the system, an environment for intervention was created before the risky time passes.

The software's ability to display information graphically will make it easier to observe changes in animal states. Since instant data tracking will be difficult in human-based observation, this system can also provide a backward control mechanism. The availability of a database will make it easier to access the animals' discomfort information and retrospectively, preventing errors and wasting time.

With this system, changing data in the environment (temperature, pH) is provided to be taken wirelessly within the specified intervals. As the system can be developed, it can be used as a native application to veterinarians in the fields of cattle breeding and fattening.

CONCLUSION

It is seen that the installed system and device are compared with the devices operating at the same time, the cost is low, and the size is small. It can be ensured that the designed circuit can be used in non-cannulated animals in later stages.

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