SALAGA Journal
Vol. 03, No. 2, December 2025, pp. 68~75
ISSN: 3032-2677
DOI: 10.70124/salaga.v3i2.2134

ESP32 IoT Auger-Based Automatic Feeder for Fish Pellets

Aqid Mukhtar[1], Ahmad Munir[*2], and Abdul Azis[2]
[1]Postgraduate Student, Hasanuddin University, Makassar, Indonesia
[2]Faculty of Agricultural Technology, Hasanuddin University, Makassar, Indonesia

Article Info

Article history:

Received 11 16, 2025
Revised 12 23, 2025
Accepted 12 25, 2025

Keywords:

Aquaponics
Auger
Automatic feeders
ESP32
IoT

ABSTRACT

Manual fish feeding in aquaponics often leads to inconsistent schedules and imprecise dosing, degrading water quality and system performance. This study designs and builds an ESP32-based IoT automatic fish feeder using an auger dispensing mechanism controlled via the Blynk platform. The objectives are to develop a reliable feeder, calibrate dosing for different pellet sizes (1, 2, and 3 mm), and evaluate scheduling accuracy and dosing precision. The prototype consists of a 3 kg acrylic hopper (45° angle of repose), a cast-iron auger, and an ESP32 control module with a servo and DC motor driven by an L298N driver. Calibration established linear models between servo rotation time and feed dose, and between motor PWM and throwing distance. Performance tests were conducted over three days with twice-daily feeding. Results show strong linearity in calibration (dose–time $R^2 > 0.997$; PWM–distance $R^2 > 0.92$), perfect schedule adherence (zero delay at 08:00 and 15:00), and high dosing accuracy across pellet sizes, with average errors of 2.37% (1 mm), 3.04% (2 mm), and 2.94% (3 mm) (overall mean 2.78%). In conclusion, the system integrates mechanical reliability, electronic control, and IoT accessibility to deliver precise, scheduled, and remotely controllable feed management for aquaponics. The approach is practical and low-cost, and it contributes to smart aquaculture by enhancing operational efficiency and reducing labor dependency.

Corresponding Author(s):

Ahmad Munir
Faculty of Agricultural Technology, Hasanuddin University
Jl. Perintis Kemerdekaan KM.10, 90245, Tamalanrea, Makassar, Sulawesi Selatan, Indonesia
Email: amunir@unhas.ac.id

1. INTRODUCTION

Aquaponics is an innovative agricultural technique that combines aquaculture, the practice of fish farming, hydroponics, and the cultivation of plants without soil within a closed-loop recirculating system. In this mutually beneficial relationship, fish waste supplies essential nutrients to plants, and the plants function as biofilters, purifying water for the fish(Love et al., 2014). This system provides a sustainable method for food production, which is particularly advantageous in environments with limited space, such as urban areas. In these urban, space-constrained settings, community aquaponic initiatives have demonstrated significant potential for enhancing local food security, underscoring the necessity for straightforward and cost-effective daily automation to maintain operations (Zunaidi et al., 2024).

One of the main challenges in maintaining balance within an aquaponic system is the management of fish feeding. In small- to medium-sized systems, feeding is mostly performed manually, which can lead to inconsistent schedules and inaccurate dosing. Overfeeding and irregular feeding can cause poor water quality, nutrient imbalances, fish stress, disease outbreaks, and stunted growth (Yildiz et al., 2017). Conversely, insufficient feeding can impede fish growth and reduce the nutrient availability for plants. Therefore, precise and timely feeding is crucial for maintaining fish health, welfare, and overall productivity. From a biological standpoint, feed management, which includes the type of feed, quantity, and frequency, directly affects the feed conversion ratio (FCR), survival rate (SR), and water quality. Thus, ensuring dosing accuracy and following a schedule with automatic feeders are vital for maintaining performance and fish health, while minimizing suspended solids and biofilter load (Fradina & Latuconsina, 2022; Yildiz et al., 2017).

Recent advancements have introduced automatic feeders; however, their limitations persist. Certain designs encounter challenges with feed bridging or jamming, particularly when dealing with varying pellet sizes (Maulana, 2022). Additionally, some systems lack remote monitoring and control capabilities, thereby reducing the flexibility available to farmers (Putra & Aisuwarya, 2022). Furthermore, many systems do not incorporate dosing calibration based on the feed type, resulting in inaccurate feed delivery. From a mechanical perspective, the hopper design for fish pellets should consider the angle of repose of the material. Setting wall angles steeper than the static repose angle aids in preventing bridging or arching and ensures stable mass flow (Al-Hashemi & Al-Amoudi, 2018). The repose angle should be measured (e.g., cone-on-plate heap method) to ensure that the design angles are explicitly above the measured value (Miura et al., 1997).

This study created an automatic fish feeder using IoT technology. It uses an auger system controlled by an ESP32 microcontroller and the Blynk platform. ESP32 is already known to work well for automating and monitoring in farming (Fadil et al., 2023). The study also adjusted the feeder for different pellet sizes (1, 2, and 3 mm) and checked how well it worked for timing, dosing, and remote control. By combining the auger's mechanical reliability, ESP32's electronic control, and Blynk's IoT access, this research helps develop smart and precise feeding systems for sustainable aquaponics. In Indonesia, a similar feeder in aquaponics has been noted for its ability to sync feeding schedules and water quality checks, showing the importance of affordable and precise IoT feeders for small farms (Afandi, 2021).

2. MATERIALS AND METHODS

2.1. Materials and Equipment

The hardware components used in this study included a NodeMCU ESP32 microcontroller, an MG996R servo motor, a 12V DC motor, and an L298N motor driver. Power was supplied via a 12V adapter, and connectivity was established using jumper cables. The device was programmed using an Arduino IDE (v2.3.2) and integrated with the Blynk IoT platform (v2.0) for remote control. Design and modeling were performed in Fritzing, while the data were processed in Microsoft Excel. Calibration and measurement were conducted using a digital scale (accuracy: 0.01 g) and a meter. The fabrication tools included a welding machine, grinding tools, glue gun, and general workshop equipment.

The construction materials comprised PVC pipe (Ø4 cm), acrylic sheets (2 mm thickness), cast iron (shaft), and plate iron (auger screw). Fish feed pellets of three sizes (1, 2, and 3 mm) were used for calibration and performance testing.

2.2. System Design

The feeding system consisted of a hopper, an auger-based dispensing unit, and an IoT-enabled control module. The hopper was designed with a 45° angle of repose to ensure a stable mass flow and minimize bridging/arching for fish pellets, the hopper wall slope was set steeper than the measured static angle of repose of the pellets; the repose angle (α) was determined via the cone-on-plate heap method, measuring heap height (h) and diameter (D), with $\alpha = \arctan(2h/D)$. This procedure provides a materials-based design parameter and is consistent with granular flow fundamentals reported in the literature (Al-Hashemi & Al-Amoudi, 2018; Miura et al., 1997). An auger (screw conveyor) was used to meter and transfer feed pellets, chosen for its stable discharge rate (Chongchitpaisan & Sudsawat, 2022). The control system was built around the ESP32, which communicated with the Blynk app via Wi-Fi, allowing manual and scheduled feeding.

A block diagram of the control system is shown in Figure 1. ESP32 served as the central controller, receiving commands from Blynk and sending signals to the L298N driver and servo motor. L298N regulates the DC motor speed via PWM, while the servo rotates the auger shaft.

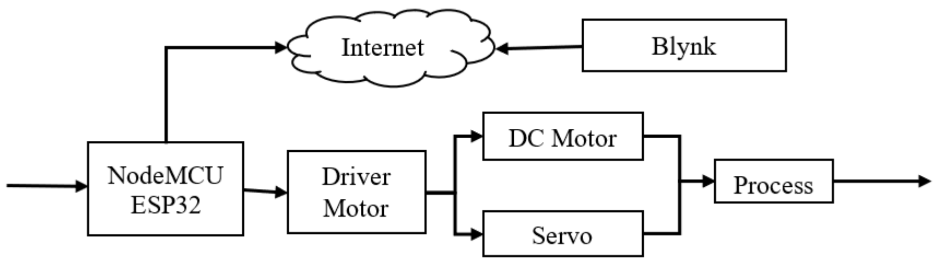

Figure 1. Block diagram of the control system.

2.3. Research Procedure

This study adhered to a systematic protocol for development and testing.

1. Design Phase: Mechanical components, specifically the hopper and auger, were modeled using SolidWorks. The control logic and Internet of Things (IoT) interface were developed using the Arduino Integrated Development Environment (IDE) and Blynk.
2. Fabrication and Assembly: The components were fabricated and assembled into a functional prototype
3. Calibration: A linear regression analysis was conducted to establish the relationship between the servo rotation time (1–10 s) and feed dose for each pellet size. Similarly, the pulse-width modulation (PWM) of the DC motor (50–255) was calibrated in relation to throwing distance.
4. Functional Testing: The responsiveness of the system to both manual and automatic commands was evaluated using Blynk.
5. Performance Testing: The accuracy of feeding and adherence to the scheduled feeding times were assessed over a period of three days, with two feeding sessions conducted daily at 08:00 and 15:00.

2.4. Calibration Method

Calibration was conducted to ensure dosing accuracy. For each feed size (1, 2, and 3 mm), the auger was rotated for durations from 1 to 10 s, and the discharged feed was weighed. A linear regression model was used to fit the data. The same approach was used for throwing distance versus PWM. The resulting equations are embedded in the controller firmware.

2.5. Performance Metrics

The following parameters were evaluated:

- Schedule adherence: Difference between programmed and actual feeding times.
- Dosing accuracy: Measured using error formula

$$\text{Error (\%)} = \frac{|Y-X|}{X} \times 100 \quad (1)$$

where Y is the actual dose discharged (g) and X is the target dose (g).

- System reliability: Ability to perform consistently over repeated cycles.

2.6. Data Analysis

Data were descriptively analyzed using linear regression in MS Excel. Error values were averaged across replicates, and the coefficient of determination (R^2) was used to assess the calibration fit.

3. RESULTS AND DISCUSSION

3.1. Hardware Design and Prototype

The automatic feeder was successfully designed and fabricated with a total hopper capacity of 3 kg, comprising a 2.5 kg rectangular section and a 0.5 kg truncated pyramid section (Figure 2). The hopper was constructed from 2 mm acrylic with a 45° repose angle to prevent feed bridging. The auger (Figure 3), made from cast iron (shaft) and plate iron (screw), had an outer diameter of 3.95 cm, a pitch of 2 cm, and was driven by an MG996R servo motor. The control system integrated an ESP32 microcontroller, an L298N motor driver, and a 12V DC motor for feed dispersal. The complete prototype is shown in Figure 7.

(a) (b)

Figure 2. Comparison of Hopper Designs: (a) CAD and (b) prototype.

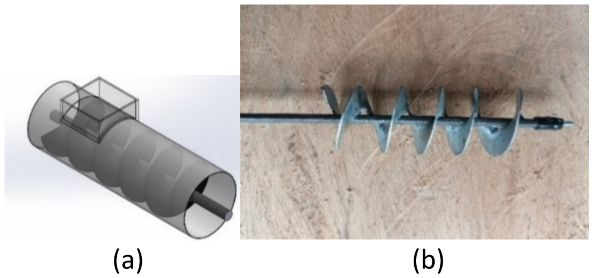

Figure 3. Comparison of auger designs: (a) CAD and (b) prototype.

3.2. Control System Design

The control system was developed using the Fritzing software, with a focus on the ESP32 microcontroller, as illustrated in Figure 4. This microcontroller facilitates Wi-Fi connectivity, thereby enabling communication with smartphones. The MG996R 360-degree servo motor was chosen to rotate the auger for the movement of granular materials, whereas the L298N motor driver was employed to control the DC motor. The DC motor operates at 12V to dispense feed when activated by the auger. Time-based servo actuation (open-loop on/off) was used as the metering variable for the auger; this low-cost strategy is widely adopted in servo-driven manipulation prototypes (Latifa & Saputro, 2018).

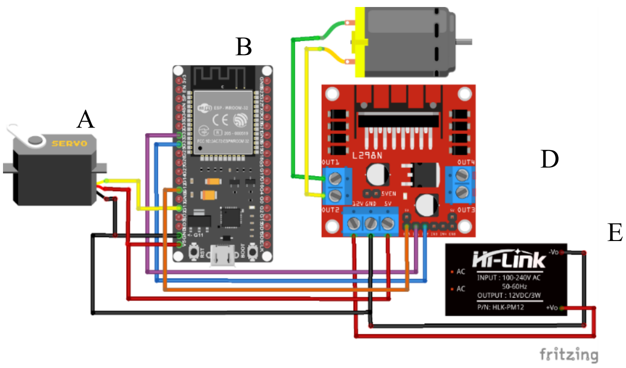

Figure 4. Design of feed device control system.

The control module prototype, as depicted in Figure 5, comprises the primary components: the NodeMCU ESP32, L298N motor driver, MG996R servo motor, and DC motor connections. The ESP32 functions as a microcontroller, tasked with receiving schedules and transmitting commands to the actuators while simultaneously maintaining connectivity with smartphones via Wi-Fi.

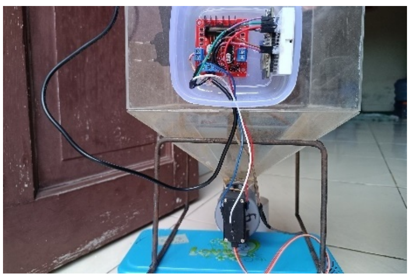

Figure 5. Illustration of the control module position on the prototype.

3.3. Software and IoT Integration

The system was fully integrated with the Blynk IoT platform, allowing both manual and automatic control via a smartphone. Users can set feeding schedules, adjust doses (1-60 g), and control throwing distance (PWM 50-255). ESP32 provides stable Wi-Fi connectivity with no communication failures observed during testing.

The Blynk application interface (Figure 6) provides two control modes: manual control for immediate feeding and automatic control for scheduled feeding. In the manual mode, users can set the desired feed dose and spreading distance. In the automatic mode, feeding schedules can be programmed, and the device operates automatically when scheduled times arrive.

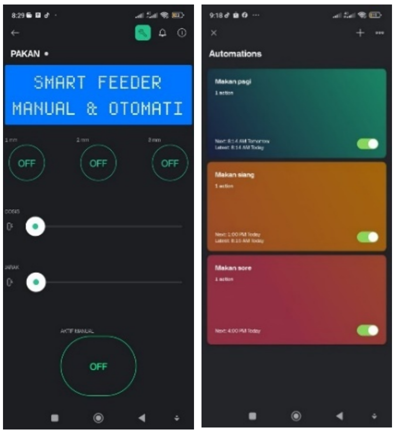

Figure 6. Blynk application interface: (a) manual control, (b) automatic control.

3.4. Complete Prototype Assembly

Following the assembly of the hopper, auger, and control system components, the complete prototype (Figure 7) underwent performance testing. The device is capable of immediate operation with manual control via Blynk, without the need for schedule settings, or can function automatically according to predetermined feeding schedules. The ESP32 microcontroller receives commands from Blynk, instructs the servo to rotate the auger, and activates the DC motor with speed and duration settings configured on the Blynk platform.

Figure 7. Complete automatic feeder prototype.

3.5. Calibration Results

Calibration was performed to establish precise relationships between servo rotation time and feed dose for three pellet sizes (1, 2, and 3 mm). Strong linear correlations were observed, with R^2 values exceeding 0.997 (Table 1). Similarly, the DC motor PWM was calibrated against the throwing distance, with R^2 values ranging from 0.922 to 0.984 across pellet sizes (Table 2). High R^2 values indicate reliable predictability, which is critical for consistent field performance (Srivastava et al., 1993).

Table 1. Calibration equations for feed dose vs. servo rotation time

Feed size (mm)	Linear equation	R^2 value
1 mm	y=375.35x+172.5	0.9994
2 mm	y=390.92x+101.28	0.9986
3 mm	y=455.65x−24.702	0.9975

Table 2. Calibration equations for throwing distance vs. motor PWM

Feed size (mm)	Linear equation	R^2 value
1 mm	y=0.8825x−5.165	0.9836
2 mm	y=1.4029x−245.12	0.9222
3 mm	y=1.4751x−400.53	0.9378

Note: y = PWM value, x = throwing distance (cm)

The calibration equations were integrated into the controller firmware to facilitate the automatic adjustment of the servo rotation time and motor PWM, contingent upon the user-selected feed size and specified dose or distance. Because particle size and moisture content influence discharge behavior, the dose–time calibration was performed separately for each pellet size to capture material-dependent flow characteristics (Al-Hashemi & Al-Amoudi, 2018)

3.6. Functional Testing

The feeder responded correctly to all manual commands via Blynk (Table 3). In the automatic mode, the system was activated precisely at scheduled times (08:00 and 15:00) over three consecutive days with zero delay (Table 4). This demonstrates robust real-time clock management and IoT synchronization, addressing a key limitation of earlier systems that lacked schedule reliability (Maulana, 2022).

Table 3 Manual control response test results

Trial	Command	Servo Response	DC Motor Response
1	ON	Active	Active
2	ON	Active	Active
3	ON	Active	Active

Table 4. Automatic schedule adherence test results

Day	Scheduled Time	Actual Activation Time	Delay (seconds)
1	08:00 & 15:00	08:00 & 15:00	0
2	08:00 & 15:00	08:00 & 15:00	0
3	08:00 & 15:00	08:00 & 15:00	0

While functional tests under stable Wi-Fi conditions demonstrate perfect schedule adherence without delays, real-world deployments in agricultural settings often encounter intermittent connectivity and variable latency on IoT links. Field reports suggest that cloud monitoring platforms can experience multi-second delays and data loss in rural areas, with REST/MQTT round-trip times typically ranging from 1 to 3 seconds. Moreover, uplinks tend to be more variable than downlinks (Jamaluddin et al., 2025; Viegas et al., 2021). To ensure reliable feeding under these conditions, it is advisable to implement a local first architecture where all schedules and dosing calculations are executed on the ESP32. In local small-scale implementations, an integrated automatic feeder with aquaponics, emphasizing scheduled feeding and water-quality monitoring, supports the choice of a low-cost IoT architecture (Afandi, 2021).

3.7. Dosing Accuracy Performance

Dosing accuracy was evaluated across three target doses (15, 35, and 55 g) and three pellet sizes (Table 5). The average dosing error was low across all sizes: 2.37% for 1 mm, 3.04% for 2 mm, and 2.94% for 3 mm pellets. The overall mean error was 2.78% (SD = 0.35%), which is comparable to or better than previously reported values for agricultural metering systems (Rantawi, 2013). From a husbandry standpoint, keeping dosing errors below ~5% helps avoid overfeeding-induced suspended solids and biofilter overload, thereby supporting FCR/SR targets and water-quality stability (Fradina & Latuconsina, 2022; Yildiz et al., 2017)

Table 5. Dosing accuracy test results across pellet sizes

Target Dose (g)	1 mm		2 mm		3 mm	
	Actual (g)	Error (%)	Actual (g)	Error (%)	Actual (g)	Error (%)
15	15.62	4.13	15.61	4.07	15.74	4.93
35	35.2	0.57	35.83	2.37	35.73	2.09
55	56.32	2.4	56.5	2.73	56.01	1.84
Average Error		2.37		3.04		2.94

Slightly higher errors for 2 mm pellets may be attributed to irregular pellet geometry or minor inconsistencies in auger engagement. Nevertheless, all errors remained below 5%, which is acceptable for most aquaculture applications (Yildiz et al., 2017).

3.8. Discussion

Compared with the servo-gate design by Maulana (2022), which experienced feed bridging, our auger-based approach ensured consistent discharge across all pellet sizes. In addition, unlike the standalone automatic feeder described by Putra and Aisuwarya (2022), our system integrates full IoT capabilities, enabling remote scheduling, dose adjustment, and real-time monitoring, which is a significant advancement in smart aquaculture automation. In the context of urban community farming, the implementation of a cost-effective IoT feeder that minimizes labor while ensuring adherence to scheduling can support the sustained operation of such initiatives in resource-limited settings (Zunaidi et al., 2024).

Although the prototype performed reliably under controlled conditions, several factors should be considered for field deployment: environmental exposure (acrylic may degrade under UV light), power dependency (requires uninterrupted power/Wi-Fi), and feed humidity (may cause clogging). Future designs could incorporate UV-resistant materials, battery backups, and moisture protection.

4. CONCLUSION

This study successfully developed, fabricated, and evaluated an Internet of Things (IoT)-based automatic fish feeder for aquaponic systems. The system incorporates an auger dispensing mechanism, ESP32 microcontroller, and Blynk IoT platform for remote control and scheduling.

The principal findings are as follows:

1. Hardware Implementation: The feeder was constructed with a 3 kg acrylic hopper featuring a 45° repose angle, a cast iron auger with a diameter of 3.95 cm and a pitch of 2 cm, and an ESP32-based control system. The prototype exhibited robust mechanical and electronic performance.
2. Calibration Accuracy: Strong linear relationships ($R^2 > 0.997$) were established between servo rotation time and feed dose across three pellet sizes (1, 2, and 3 mm). Similarly, the calibration of pulse-width modulation (PWM) to the throwing distance yielded R^2 values exceeding 0.92.
3. Operational Reliability: The system operated precisely according to scheduled feeding times (08:00 and 15:00) with zero delay over three consecutive days, confirming reliable IoT connectivity and real-time control.
4. Dosing Precision: The average dosing errors were 2.37% for 1 mm pellets, 3.04% for 2 mm pellets, and 2.94% for 3 mm pellets, with an overall mean error of 2.78%. All errors remained below 5%, meeting practical aquaculture requirements.

REFERENCES

Afandi, R. (2021). *Rancang Bangun Alat Pemberian Pakan Ikan Otomatis dan Aquaponik untuk Menjaga Kualitas Air pada Kolam Ikan Patin* [Bachelor Thesis, UIN SUSKA Riau]. http://repository.uin-suska.ac.id/53835/

Al-Hashemi, H. M. B., & Al-Amoudi, O. S. B. (2018). A Review on The Angle of Repose of Granular Materials. *Powder Technology*, *330*, 397–417. https://doi.org/https://doi.org/10.1016/j.powtec.2018.02.003

Chongchitpaisan, P., & Sudsawat, S. (2022). A Review on Screw Conveyors for Bulk Materials in Various Applications. *Ladkrabang Engineering Journal*, *39*(2), 1–12.

Putra, T. D., & Aisuwarya, R. (2022). Sistem Kontrol dan Monitoring pH serta Pemberian Pakan Ikan Otomatis pada Aquaponik Berbasis Mikrokontroller. *CHIPSET*, *3*(01), 73–82. https://doi.org/10.25077/chipset.3.01.73-82.2022

Fadil, M., Ahmad Munir, & Muhammad Tahir Sapsal. (2023). On-Off Water Level Control and IoT Monitoring for Aquaponics Systems. *Salaga Journal*, *1*(2), 90–100. https://doi.org/10.70124/salaga.v1i2.1355

Fradina, I. T., & Latuconsina, H. (2022). Feeding Management for Nile tilapia (Oreochromis niloticus) Brood stock and Seed in the Aquaculture Installation, Kepanjen-Malang Regency. *Journal of Science and Technology*, *3*(1), 39–45.

Jamaluddin, A. A. T., Faridah, S. N., Sapsal, M. T., Andini, D. A., & Ari, R. (2025). Temperature and Humidity Control in a Small-Scale Greenhouse in a Tropical Climate. *Salaga Journal*, *3*(1), 6–10. https://doi.org/10.70124/salaga.v3i1.1815

Latifa, U., & Saputro, J. (2018). Perancangan Robot Arm Gripper Berbasis Arduino Uno Menggunakan Antarmuka LabVIEW. *Barometer*, *3*(2), 138–141. https://doi.org/10.35261/barometer.v3i2.1395

Love, D. C., Fry, J. P., Genello, L., Hill, E. S., Frederick, J. A., Li, X., & Semmens, K. (2014). An International Survey of Aquaponics Practitioners. *PLoS ONE*, *9*(7), 1–0. https://doi.org/10.1371/journal.pone.0102662

Maulana, M. A. (2022). *Rancang Bangun Alat Pemberi Pakan Ikan Otomatis pada Akuarium Berbasis Internet of Things* [Bachelor Thesis]. Universitas Dinamika.

Miura, K., Maeda, K., & Toki, S. (1997). Method of Measurement for the Angle of Repose of Sands. *Soils and Foundations*, *37*(2), 89–96. https://doi.org/https://doi.org/10.3208/sandf.37.2_89

Rantawi, A. B. (2013). Perancangan Unit Transfer (Screw Conveyor) pada Mesin Pengisi Polibag untuk Meningkatkan Efektvitas Kinerja di Bidang Pembibitan. *Jurnal Citra Widya Edukasi*, *5*(1), 60–67.

Srivastava, A. K., Goering, C. E., Rohrbach, R. P., & Buckmaster, D. R. (1993). *Engineering Principles of Agricultural Machines*. American Society of Agricultural and Biological Engineers (ASABE).

Viegas, V., Pereira, J. M. D., Girão, P., & Postolache, O. (2021). Study of Latencies in ThingSpeak. *Advances in Science, Technology and Engineering Systems*, *6*(1), 342–348. https://doi.org/10.25046/aj060139

Yildiz, H. Y., Robaina, L., Pirhonen, J., Mente, E., Domínguez, D., & Parisi, G. (2017). Fish Welfare in Aquaponic Systems: Its Relation to Water Quality with an Emphasis on Feed and Faeces—A Review. *Water (Switzerland)*, *9*(1), 1–17. https://doi.org/10.3390/w9010013

Zunaidi, R. A., Annisa, A. R., Amifia, L. K., Agnia, N., Hamidah, D. N. A., Aryabawa, N. M. N., & Auliya, D. I. (2024). Implementasi Akuaponik Sebagai Upaya Urban Farming pada Lahan Kosong di Lingkungan RT9 RW9 Pepelegi Sidoarjo. *BEMAS: Jurnal Bermasyarakat*, *4*(2), 290–298. https://doi.org/10.37373/bemas.v4i2.778