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# Microcontroller Based Intelligent Volume Measurement Instrument Using Loadcells

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***Authors' contributions***

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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## ABSTRACT

This paper presents a microcontroller-based weight measurement system designed specifically for liquid agricultural produce. The system addresses the limitations of traditional volumetric methods by leveraging a load cell to convert liquid weight into an electrical signal. This signal is then digitized by an analog-to-digital converter (ADC) for processing by the microcontroller, the brain of the system. The microcontroller performs calculations, controls component operation, and displays weight data on a user-friendly interface. Additionally, a Bluetooth module enables wireless data transmission for further analysis or integration with farm management software. Performance evaluation using eight different liquid products demonstrated the system's functionality and linearity

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across a range of volumes. Future advancements could focus on incorporating higher-resolution ADCs for enhanced measurement precision and exploring automated calibration methods for improved user experience. Overall, this microcontroller-based system offers a promising alternative for efficient, accurate, and potentially farm-management integrated measurement of liquid agricultural produce.

*Keywords: ADCs; microcontroller; bluetooth module.*

## 1. INTRODUCTION

In the agricultural sector, accurate and efficient measurement of liquid produce is essential for many tasks, encompassing inventory management, product pricing, recipe formulation, and quality control. Traditional liquid measurement methods often rely on volumetric units such as liters or gallons. However, these methods can be cumbersome and error-prone, especially when dealing with viscous liquids or uneven container shapes. For instance, measuring honey or molasses using a volumetric cup can be messy and inaccurate due to the clinging nature of these substances. Additionally, uneven container shapes can lead to air pockets or inaccurate readings when using volumetric measurements. Furthermore, traditional methods necessitate cleaning and sanitizing multiple measuring containers, which can be time-consuming and increase the risk of cross-contamination [1].

This research presents a novel microcontroller-based weight measurement system specifically designed to address these challenges and enhance the efficiency and accuracy of liquid agricultural produce measurement. By leveraging weight-based measurement, the system eliminates the need for multiple measuring containers and ensures consistent results regardless of liquid viscosity or container shape. This paper describes the design, calibration procedure, and performance evaluation of a microcontroller-based weight measurement system for liquid agricultural produce. The system utilizes a load cell to convert the weight of the liquid into a measurable electrical signal. An analog-to-digital converter (ADC) then translates this analog signal into a digital format that the microcontroller can readily process [2-4]. The microcontroller acts as the brain of the system, performing calculations, controlling the operation of other components, and displaying the weight data on a user-friendly interface, such as an LCD screen. The inclusion of a Bluetooth module enables wireless data transmission to other devices, such as smartphones or tablets, for further analysis, record-keeping, or integration with farm management software. This versatile system offers several advantages over traditional volumetric measurement methods.

## 2. MATERIALS AND METHODS

### 2.1 Components of the System

A 20 kg load cell or weighing transducer to convert applied force (weight) into an electrical signal [5] an ADC (Analogue to Digital Convertor) HX711 to convert the analog signal from the load cell into a digital signal for processing by the microcontroller [6]. ATmega328P micro-controller to control the operations of all other components and perform calculations on the weight data [7] 16 x 2 LCD to display the measurement to the users [8] HC-05 Bluetooth module for wireless transmission of weight data to other devices [9] and an LM2596 DC-DC buck converter to regulate the power supply voltage to ensure consistent operation of the system is used for the current research [10]. Other agricultural products (curd, milk, buttermilk, coconut water, sunflower oil, castor oil, and ghee) used for performance evaluation of the developed microcontroller-based weight measurement system for liquid agriculture produce are purchased from the local market.

### 2.2 Design and Calibration Procedure

The system design necessitates the establishment of physical connections between its constituent components, as illustrated in Fig. 1. This critical step entails interfacing the LCD board with the load cell board to facilitate data exchange. Subsequently, both boards are connected to a power source, typically a laptop in this experiment, to supply the requisite operating voltage. The Arduino software development environment is pivotal in configuring and governing the microcontroller. The designated communication port settings are validated within this environment to ensure unencumbered communication between the Arduino software and the microcontroller embedded in the load cell board. The LCD board is then activated by powering it on, signifying the initial system initialization. Following this, the program containing the density values, weight measurement, and display algorithms is uploaded onto the microcontroller of the load cell board. This program instructs the microcontroller to process weight data acquired from the load cell and subsequently present it on the LCD. Notably, tare weight calibration is indispensable for guaranteeing precise weight measurements for the target liquid product. This process accounts for the weight of the empty container positioned on the load cell platform.

To achieve tare weight calibration, the empty container is placed on the platform, followed by a sequence of powering off and then powering on the LCD. This effectively sets the empty container's weight as the baseline (tare weight). Any subsequent weight readings will reflect the weight of the liquid product placed on the load cell platform after this calibration. Finally, liquid commercial products are intended for weight measurement is meticulously placed on the load cell platform. Its name is selected on the smart dashboard. The microcontroller processes the weight data received from the load cell and converts it into a relevant unit (e.g., Liters). The processed liquid weight value is then displayed on the LCD screen for convenient visualization.

### 2.3 Algorithm

This algorithm outlines the operational flow of the microcontroller-based liquid weight measurement system. It begins by initializing the microcontroller and configuring communication with the load cell and analog-to-digital converter (ADC). The load cell, acting as a weight sensor, converts applied force into an electrical signal read by the microcontroller. The ADC then digitizes this analog signal for processing. The raw digital data undergoes calibration and scaling to account for sensor variations and translate the value into a meaningful unit (liters). Additionally, the system monitors battery voltage using the ADC to track its health. Processed weight data is then used for application-specific calculations or actions based on fixed thresholds. Finally, the weight is displayed on an LCD or transmitted wirelessly. This process repeats continuously, enabling the system to constantly monitor the load cell and measure the weight of agricultural products directly in Liters placed on it.

## 3. RESULTS AND DISCUSSION

### 3.1 Performance Evaluation

The performance of the microcontroller-based liquid weight measurement system has been verified against 8 different liquid products (curd, milk, buttermilk, water, coconut oil, sunflower oil, castor oil, and ghee) as shown in Table 1 and all the products were measured in triplicates. Fig. 2 presents the results and trendline of the liquid-weight measuring system using the programmed density value of the product. Initial trials were performed for 0.1 L, 0.25 L, 0.5 L, and 1 L quantity products and the linearity of the load cell sensor applied in the system has been proved. Besides, the accuracy of the developed microcontroller-based liquid weight measurement system was compared to a standard weighing scale (where liquid volume in liters was manually calculated using the product's density) and the results are presented in Table 1.

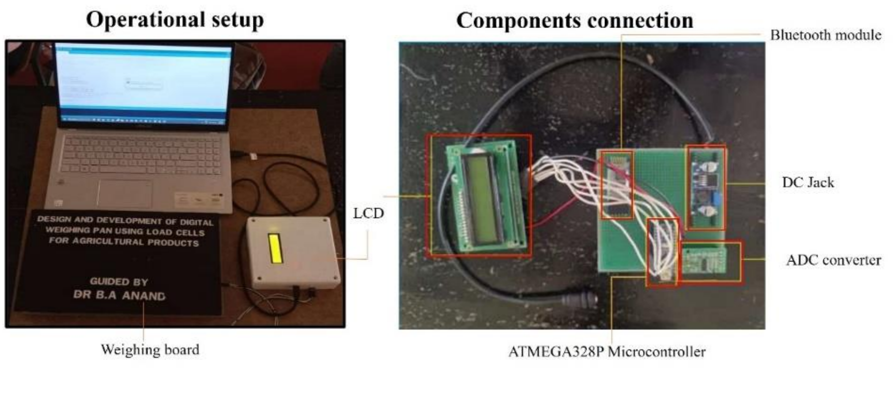


**Fig. 1. Components and operational setup of microcontroller-based liquid weight measurement system**

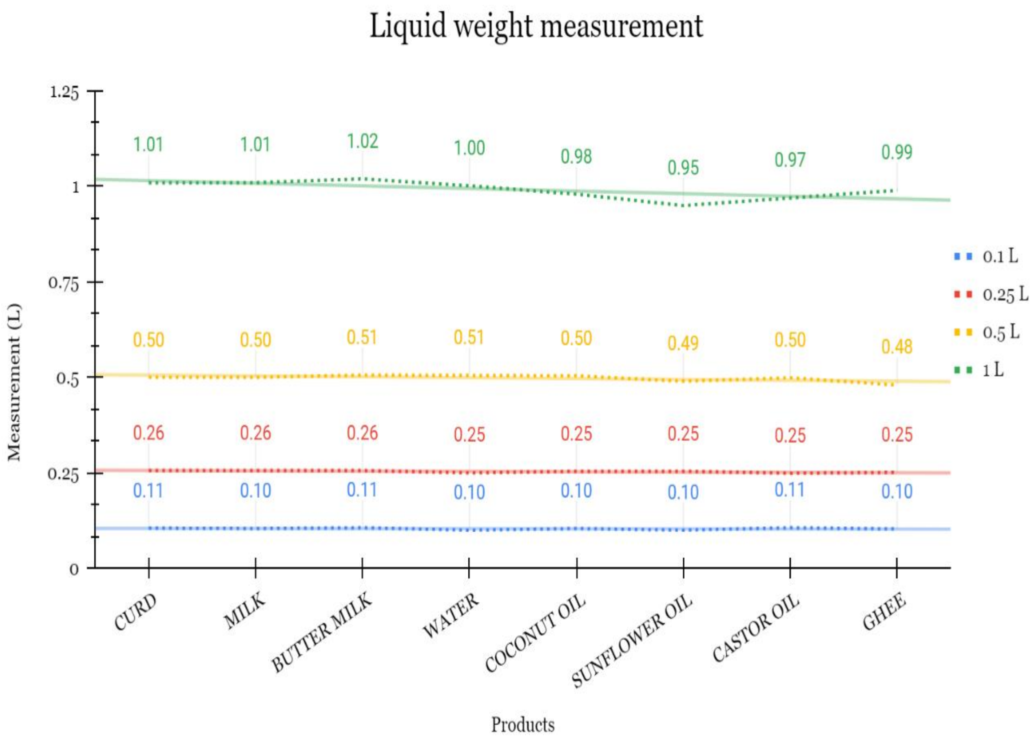


**Fig. 2. Agricultural produce measured (in Liters) in the microcontroller-based liquid weight measurement system**

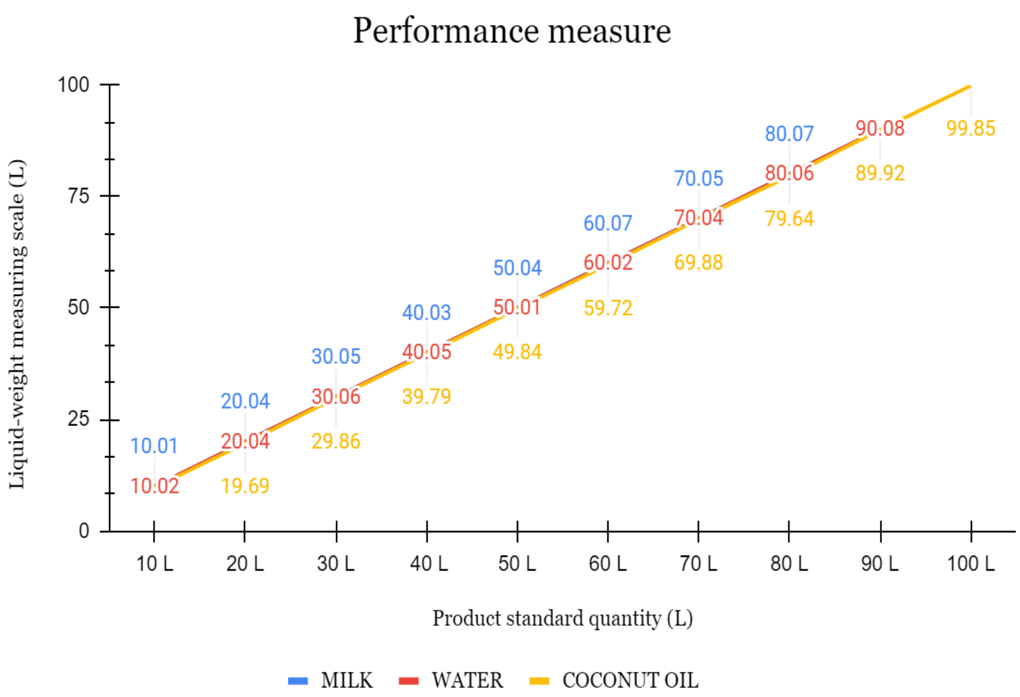


**Fig. 3. Agricultural produce measured (in Liters) in the microcontroller-based liquid weight measurement system till 100 L**

**Table 1. Microcontroller-based liquid weight measurement system (MLMS) and Standard Weighing Scale (SWS) measured Volumetric weights**

| Standard value/ | 0.1 L | | 0.25 L | | 0.5 L | | 1 L | |
|---|---|---|---|---|---|---|---|---|
| Products | MLMS | SWS | MLMS | SWS | MLMS | SWS | MLMS | SWS |
| CURD | 0.11 | 0.11 | 0.26 | 0.26 | 0.50 | 0.52 | 1.01 | 1.03 |
| MILK | 0.10 | 0.10 | 0.26 | 0.26 | 0.50 | 0.52 | 1.01 | 1.04 |
| BUTTERMILK | 0.11 | 0.11 | 0.26 | 0.27 | 0.51 | 0.53 | 1.02 | 1.05 |
| WATER | 0.10 | 0.10 | 0.25 | 0.26 | 0.51 | 0.51 | 1.00 | 1.05 |
| COCONUT OIL | 0.10 | 0.10 | 0.25 | 0.23 | 0.50 | 0.47 | 0.98 | 0.84 |
| SUNFLOWER OIL | 0.10 | 0.09 | 0.25 | 0.23 | 0.49 | 0.41 | 0.95 | 0.84 |
| CASTOR OIL | 0.11 | 0.10 | 0.25 | 0.24 | 0.50 | 0.48 | 0.97 | 0.86 |
| GHEE | 0.10 | 0.12 | 0.25 | 0.29 | 0.48 | 0.53 | 0.99 | 1.04 |

Additionally, the calibration of the developed system is evaluated by measuring 3 samples with different product densities (milk: 1.03 g/ml, water: 1 g/ml, and coconut oil: 0.93 g/ml). Fig. 3 graph shows that the microcontroller-based liquid weight measurement system is very linear and suitable for measuring the weight of any agricultural liquid product. The maximum quantity of the liquid that can measured in the developed system is 100 L, an error occurred in the case of milk and water during the 100 L measuring.

This research proposes a comprehensive design for a microcontroller-based liquid weight measurement system, encompassing both hardware and software components. While the design offers a functional solution, there is potential to enhance system accuracy through specific refinements. The implementation of higher-resolution analog-to-digital converters (ADCs) would elevate the measurement precision of the system. Higher-resolution ADCs translate analog signals into digital data with greater fidelity, minimizing quantization errors and yielding more accurate weight measurements.

## 4. CONCLUSION

This research successfully developed and evaluated a microcontroller-based weight measurement system designed specifically for liquid agricultural produce. The system leverages a load cell to convert liquid weight into a measurable electrical signal, which is then digitized by an analog-to-digital converter (ADC) for processing by the microcontroller. The microcontroller acts as the central processing unit, performing calculations, controlling component operations, and displaying weight data on a user-friendly interface. The inclusion of a Bluetooth module enables wireless data transmission for further analysis, record-keeping, or integration with farm management software. Performance evaluation using various liquid agricultural products demonstrated the system's functionality and linearity across a range of volumes. Future advancements could focus on incorporating higher-resolution ADCs to enhance measurement precision and exploring automated calibration methods for improved user experience. Overall, this microcontroller-based weight measurement system offers a promising alternative to traditional volumetric measurement methods for liquid agricultural products, promoting efficiency, accuracy, and potential integration with farm management practices.

## DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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