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Design and Development of an Arduino Based Sensor Integrated Eco-Friendly Curd to Butter Milk Converter

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Abstract: We built an eco-friendly curd-to-buttermilk converter packed with sensors, all run by an Arduino Uno. The goal? Make something sustainable and smart. Instead of new materials, we used old food-grade pipes—so there's less waste, but everything stays clean and tough. For the actual churning, a 12V DC motor gets the job done. The relay keeps the high and low voltage parts separated, so it's safe. The automation side is pretty clever. The ACS712 current sensor keeps an eye on the load—when it senses the curd's turned to buttermilk, it shuts off the motor to avoid over-churning and wasting power. The LM35 temperature sensor checks that things don't get too hot; if they do, it cuts the motor to keep everything safe. We added a 555 timer IC to make sure the machine doesn't just run forever. And for a bit of user-friendliness, LED lights show what's happening in real time. It's reliable, easy on the wallet, and fits perfectly in homes or small dairies out in the country.

Keywords: Capacitive moisture sensor, DS18B20 sensor, ESP32, Heating element.

1. Introduction

Dairy products like curd and buttermilk are staples in many households, especially in rural areas where people still rely on traditional ways to make them. The old-school churning methods? They take a lot of time and effort, and you never really know what you'll get—sometimes the quality's all over the place. Wooden churners, for example, soak up moisture and are tough to clean, so hygiene's a real issue. Plus, you can't really keep an eye on the process as it happens, so it's easy to over-churn, waste energy, and end up with a product that's not quite right. All these problems just point to one thing: it's time for a better, automated, and cleaner way to handle dairy processing—something that saves time, keeps things hygienic, and makes life a little easier.

That's where this new system steps in. It mixes smart design with modern tech. Instead of new plastics or metals, it uses recycled food-grade pipes for the housing—so, less waste and more reuse, which fits right in with the whole circular economy idea. The setup is tough, hygienic, and doesn't break the bank, making it perfect for rural families or small dairy businesses. At its heart, a 12V DC motor does the churning, using less power but still getting the job done. Safety's covered, too—a relay switch keeps the low-power Arduino controller separate from the high-power motor, so there's no risk of frying the electronics. By putting recycled materials and efficient parts together, the system keeps its environmental impact low and proves that sustainable engineering isn't just talk—it can actually make daily food prep better.

The real game-changer here is automation. An Arduino Uno runs the whole show, bringing together sensors for precise control. The ACS712 current sensor tracks how hard the motor's

working, so it knows exactly when the curd changes into buttermilk. When it hits that sweet spot, the Arduino shuts the motor off—no more guesswork, no wasted energy. There's also an LM35 temperature sensor, always checking the heat—if things get too hot, the system shuts down to keep the batch safe. A 555-timer chip guarantees the motor runs for at least a minimum time, and it steps in if a sensor ever fails, so the machine doesn't go haywire. Simple LED lights give live updates, making things easy for anyone using it.

Figure 1: *Illustration of the Curd to Buttermilk Machine*

What really matters about this project is how it brings sustainability and technology together. By reusing materials, cutting down on energy use, and automating the whole process, it directly supports goals like responsible consumption and climate action. It's affordable, so rural families can run their own dairy processing without needing big factories. Small businesses can use it too, boosting what they produce, cutting out some of the heavy labor, and keeping food safer. At the end of the day, this project shows how electrical and electronics engineering can make a real difference—offering eco-friendly, practical solutions for food processing that actually help people in their everyday lives.

2. Literature Review

Kumar S. and Patel R. (2019) introduced their work "Design and Implementation of an Automated Dairy Processing System" in the International Journal of Engineering Research and Applications. This study highlights the use of Arduino Uno R3 as the primary controller, managing a 12 V SPDT relay to drive a high-torque DC motor. Pulse Width Modulation (PWM) was applied to regulate motor speed, ensuring uniform churning of dairy products. The authors emphasized automation as a means to improve consistency, reduce manual effort, and enhance energy efficiency in small-scale dairy processing.

Rahaman M. A. and Singh T. J. (2020) presented "Current Sensor Based Automation for Industrial Mixing Applications" in the Journal of Electrical Engineering and Technology. Their research focused on the integration of the ACS712 Hall-effect current sensor with analog-to-digital signal processing to monitor motor load. The system enabled real-time detection of consistency changes and triggered automated shutdown once optimal mixing was achieved. This approach demonstrated significant energy savings and improved reliability in industrial mixing processes.

Chen L. and Gupta H. (2021) published "Temperature Monitoring and Safety Protocols in Food Processing" in the Global Journal of Dairy Science and Technology. The study explored the use of the LM35 precision linear sensor for continuous thermal feedback. Automated emergency shutdown logic was implemented to maintain food safety and prevent overheating of equipment. The authors concluded that integrating temperature monitoring into dairy systems enhances both product quality and operational safety.

Williams J. O. and Mehta K. L. (2022) introduced "Sustainable Design in Rural Agricultural Tools Using Recycled Materials" in the International Journal of Sustainable Engineering. Their work demonstrated the use of food-grade PVC housing and repurposed structural pipes to promote circular economy principles. The study emphasized durability, hygiene, and low-power embedded control systems, making the design suitable for rural agricultural applications. This research provided a strong foundation for eco-friendly mechanical frameworks in dairy equipment.

Rahman M. A. and Singh T. J. (2021) presented "Current Sensor Based Automation for Industrial Mixing Applications" in the Journal of Electrical Engineering and Technology. This paper analyzed the role of ACS712 sensors in detecting viscosity

changes during mixing. By monitoring motor load variations, the system achieved automated motor shutdown at the precise point of optimal mixing. The authors highlighted the importance of sensor-based automation in reducing energy consumption and improving process accuracy.

Suresh M. and Varma A. (2023) published "Embedded Control Systems for Sustainable Rural Dairy Equipment" in the Journal of Rural Development and Engineering. Their research focused on low-power microcontroller applications for consistency monitoring in dairy processing. The system improved productivity in rural settings by automating curd-to-buttermilk conversion while minimizing energy usage. The authors emphasized that embedded control systems can empower rural communities with cost-effective and sustainable dairy solutions.

3. Description of Existing System

Right now, turning curd into buttermilk still relies on old-school wooden tools and a lot of manual churning. It's a tough job—takes a lot of time and really wears people out. You end up with shaky results because it's hard to keep a steady rhythm by hand. Plus, wooden tools soak up all sorts of stuff, so cleaning them properly is a pain. That means the curd can pick up bacteria, which isn't great for hygiene. There's no way to check the consistency or temperature as you go, either. People just have to guess when it's done. So, it's easy to overdo it and mess up the batch, wasting energy and getting buttermilk that's sometimes just not good enough.

4. Challenges in the Existing System

Turning curd into buttermilk isn't as smooth as it should be. Manual churning takes a lot of effort, and honestly, it wears people out fast. The rotation speed keeps changing too, so you never really get the same result twice. Those old wooden churners? They soak up whatever touches them, so cleaning is a hassle and germs can hang around—definitely not great for hygiene or safety. Plus, there's no way to check the consistency or temperature as you go. People just guess and hope for the best, which means it's easy to overdo it, waste energy, and end up with buttermilk that doesn't really hit the mark. In the end, the whole thing feels outdated, inefficient, and just doesn't fit with what today's dairy operations really need.

5. Proposed System

This system takes the old chore of making buttermilk and gives it a fresh, eco-friendly twist. Instead of relying on manual labour, it uses a smart, compact design built from recycled food-grade pipes—so it's tough, clean, and good for the planet. You can set it up at home or in a small dairy, and it won't break the bank. At its heart, there's a 12-volt DC motor doing the churning. That means you get smooth, steady mixing every time, without all the effort. The motor connects to a relay-based switch, so the Arduino Uno microcontroller can run the show without risking any electrical hiccups. This setup keeps things safe and dependable by keeping the low-power control circuit and the high-power motor separate. By using recycled materials and smart electronics, this machine proves you can build greener, more reliable food processing gear without sacrificing performance.

Automation sits at the heart of this system. The Arduino Uno takes charge, pulling in data from sensors and running the motor. They've built in an ACS712 current sensor to keep an eye on how much work the motor's doing during churning. As curd turns into buttermilk, the mix gets less thick, and the sensor spots this change. When that happens, it tells the Arduino to switch off the motor, so you don't over-process the batch. That saves energy and keeps the product consistent. To keep things safe, an LM35 temperature sensor tracks the heat nonstop. If things start to get too hot, the Arduino jumps in and shuts everything down, protecting both the equipment and the dairy product. There's also a 555 timer IC in the mix, making sure the system runs for at least a minimum time and doesn't go on forever if a sensor messes up. All these pieces work together, so you get a system that runs smoothly, safely, and reliably every time.

The system uses LED lights to give real-time feedback, so you always know what's going on. These lights show you if the motor's running, if the sensors are working, or if there's a problem—basically, you can keep an eye on everything at a glance. This kind of visual feedback isn't just helpful; it makes the whole process more transparent and helps people trust the system, even if they're not tech-savvy. The design keeps things simple, so anyone, even folks in rural areas who might not have a technical background, can run the converter without any hassle. The system is built in a modular way, which means maintenance is straightforward and adding new features, like digital displays or wireless monitoring, is easy down the line. By blending automation with feedback that just makes sense, the system takes high-tech ideas and turns them into something practical and user-friendly for homes and small dairy businesses.

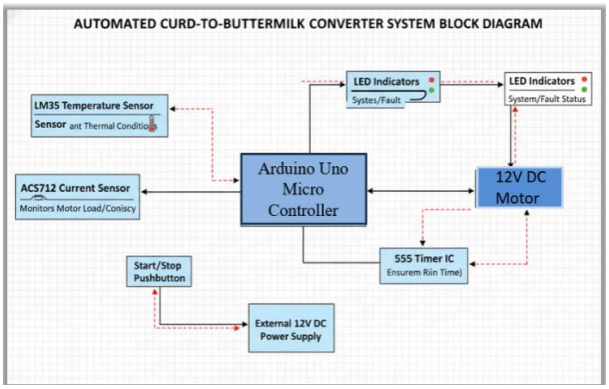

Figure 2: *Block Diagram of the Proposed System*

6. Block Diagram

6.1 Hardware Implementation

Below mentioned hardware components are used for the development of the Proposed System of Automated Water tank cleaning system using ESP32 Controller

- Arduino Uno Microcontroller
- ACS712 Current Sensor
- LM35 Temperature Sensor
- 12 V DC Motor with Relay Interface

6.1.1 Arduino Uno Microcontroller

The Arduino Uno serves as the central control unit of the system. It processes sensor inputs, executes programmed logic, and manages motor operation through relay switching. Its versatility, low cost, and ease of programming make it ideal for small-scale automation. By coordinating signals from the ACS712 current sensor, LM35 temperature sensor, and 555 timer IC, the Arduino ensures precise control, safety, and energy efficiency during the curd-to-buttermilk conversion process.

Figure 3: *Arduino Uno Board*

6.1.2 ACS712 Current Sensor

The ACS712 Hall-effect current sensor keeps an eye on how hard the motor's working while it churns. As the curd turns to buttermilk and gets thinner, the way the motor draws current shifts. The sensor picks up on these changes and lets the Arduino know what's happening. When the buttermilk hits the right texture, the Arduino shuts off the motor on its own—no guesswork needed. This stops over-processing, saves energy, and keeps every batch consistent. It's just a smarter, more dependable way to do things than handling it all by hand.

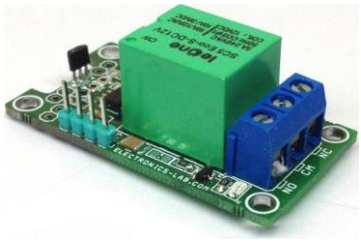

Figure 4: *ACS712 Current Sensor*

6.1.3 LM35 Temperature Sensor

The LM35 temperature sensor keeps an eye on the system's heat levels at all times. When things get too hot, it tells the Arduino to switch off the motor, stepping in to protect both the equipment and the dairy product. Because the LM35 gives a straightforward, accurate reading and hooks up

easily, it fits right into food processing setups. With this sensor on the job, you get better hygiene, no risk of overheating, and a more reliable converter overall.

Figure 5: *LM35 Temperature Sensor*

6.1.4 12 V DC Motor with Relay Interface

The 12 V DC motor does the heavy lifting when it comes to churning curd into buttermilk. It connects to a relay-based switch, so the low-power Arduino stays safe and separate from the higher-power motor circuit. That setup keeps everything running smoothly and safely. The motor spins at a steady speed, which means less work for people and better quality buttermilk every time. With the relay handling power management, this system runs efficiently and reliably—it's really the heart of the whole mechanical setup.

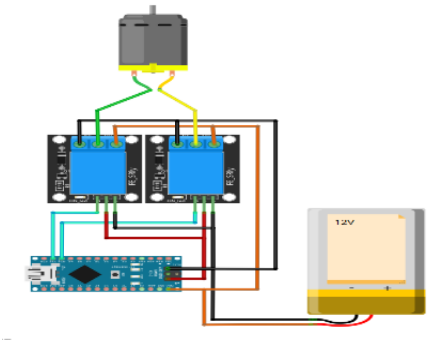

Figure 6: *12 V DC Motor with Relay Interface*

6.2 Working of Proposed System

Here's how the system works. The Arduino Uno kicks things off by turning on a 12V DC motor with a relay, so it can churn the curd. While that's happening, the ACS712 current sensor keeps an eye on how hard the motor's working—basically, it's tracking how thick the curd is as it turns into buttermilk. When the curd hits the perfect point, the Arduino shuts off the motor on its own. There's also an LM35 sensor watching the temperature; if things get too hot, it shuts everything down to keep it safe. A 555-timer chip makes sure the motor runs for at least the minimum time needed. Meanwhile, LED lights let you know what's going on in real time.

Figure 7: *Proposed System*

6.3 Operation of Proposed System

Here's how the system works. You start by putting curd into the container. The Arduino Uno jumps into action and switches on the 12V DC motor using a relay, which keeps the low-power control parts safely separated from the high-power motor. The motor then churns the curd, spinning at a steady speed and turning it into buttermilk. While all this is happening, the ACS712 current sensor keeps an eye on the motor's load. As the curd thickens or thins out, the current sensor notices any changes in power use. When the buttermilk hits the right consistency, the sensor tells the Arduino, which then shuts off the motor. This way, the machine doesn't over-process the mixture or waste energy. At the same time, there's an LM35 temperature sensor tracking the system's temperature in real time. If things get too hot, the Arduino steps in and stops the motor, protecting both the equipment and the buttermilk. There's also a 555-timer chip in the mix, making sure the machine runs for at least a minimum amount of time and never gets stuck running forever if a sensor fails.

We made this system easy to use. LED lights show what's happening in real time—things like whether the motor's running, if sensors are picking up anything, or if there's a problem. So, users always know what's going on. Even if you're not a

technical person, the modular design keeps things simple. That's especially helpful for folks in rural areas. Sensors, automation, and instant feedback all work together here. You get a process that runs smoothly, stays clean, and produces steady results. Nobody has to do the heavy lifting anymore, so there's less fatigue and better product quality. We also built this with the environment in mind. By using repurposed food-grade pipes, we cut down on waste and support the circular economy. In the end, you get a system that blends smart mechanics, safe electronics, and automation—reliable, affordable, and better for the planet. It's a real upgrade for small dairy operations.

7. Results and Discussions

It handled the curd-to-buttermilk process on its own, no fuss. The ACS712 sensor picked up on changes in the motor load, so it knew exactly when to stop—right when the buttermilk hit the perfect consistency. That meant less energy wasted and no chance of over-churning. The LM35 sensor kept an eye on the temperature and cut things off if it got too hot, so safety wasn't an issue. The 555 timer IC made sure the machine always ran for at least the minimum time it needed. LEDs let you know what was happening at a glance, so using the system felt straightforward. In the end, everything stayed cleaner, nobody had to keep checking on the process, and the buttermilk turned out the same every time. The results really showed that this eco-friendly setup works.

8. Conclusion

It uses repurposed, food-grade materials, so it's both eco-friendly and safe to use—not to mention it holds up well over time. The setup relies on ACS712 and LM35 sensors, plus a 555 timer chip, which helps keep everything precise, saves energy, and keeps the product safe. The results speak for themselves: less manual work, more consistency, and better reliability. It's affordable, too, and it really fits the needs of rural households. Using repurposed materials and smart sensors, the system cuts down on energy use, keeps things cleaner, and delivers steady product quality.

Total Cost of Hardware

Components	Cost
Arduino Uno Microcontroller	800
ACS712 Current Sensor	250
LM35 Temperature Sensor	150
555 Timer IC	50
12 V DC Motor	1200
Relay Module (SPDT)	200
LED Indicators (Set)	100
Food-Grade Pipe Housing	500
Miscellaneous (Wires, PCB, etc.)	400
Total	**3700**

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