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Smart Grocery Kit: An IoT-Based Automated Grocery Monitoring, Management, and Nutrition Recommendation System

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Abstract: A smarter way to manage groceries at home, the Smart Grocery Kit blends everyday convenience with connected technology. It centers on two smart containers that feel almost like a mini smart pantry. Each container is equipped with an RFID reader, weight sensor, air quality detector, temperature monitor, and an ESP32 microcontroller. When you drop a new item into a container, its RFID tag is scanned to pull up the product name, current quantity, and expiration date. This data is instantly shared to both a Telegram bot and a web dashboard, so you can check what you have and when you'll need to restock—without digging through drawers.The Telegram bot acts as your friendly reminder assistant. It nudges you when items are nearing their expiration, when you're running low, or if something looks like it might spoil soon. The weight sensors keep a running tally of how much of each item is left, while the air quality detector can pick up early signs of spoilage. Temperature monitoring helps ensure foods stay in their ideal conditions, so you're less likely to waste them.On the web side, a clean dashboard presents nutrition details alongside your inventory. You can see calorie counts and other essential facts for all stored items, helping you plan meals with health in mind. To keep you in the loop at a glance, an LCD display on each container shows live information—temperature, item name, and expiration date—so you always know what's going on, even without checking your phone.

Keywords: IoT, ESP32, Smart Grocery, Load Cell, DHT11, MQ3 Gas Sensor, Nutrition Recommendation, Automation, Remote Monitoring, Smart Home.

I. INTRODUCTION

In our crazy, non-stop world, keeping track of groceries feels like a full-time job. We buy stuff, shove it in the fridge or pantry, and poof—it's gone from our brains. Did we grab milk last week? Is that yogurt on its last legs? How much pasta is even left? With jobs eating up our days and evenings a blur of takeout and chaos, it's way too easy to let expiration dates slip by or ignore that funky smell starting in the crisper. The result? Tons of food hits the trash every year, burning cash and piling onto the planet's waste problem. Worse, we sometimes end up eating sketchy leftovers and regretting it later.

On top of that, most folks have no clue what's lurking in their kitchen or how good (or not) it is for them. We're all about "eating healthy" these days, but those bags of quinoa or fresh veggies just sit there forgotten until they rot. It's frustrating—we've got the good stuff, but life gets in the way.

Enter smart home tech like IoT, which is basically everyday objects chatting over the internet to make life smoother. Your lights dim on command, your thermostat learns your habits, and cameras watch the door. Why not hook up the kitchen? It's a no-brainer for cutting waste and saving time. Imagine a system that pings you: "Hey, use that chicken before tomorrow" or "Rice is low—add it to the list."

That's where the Smart Grocery Kit shines. It's a hands-off IoT setup that watches your food for you. Picture two smart bins packed with RFID scanners to read tags on your groceries, scales to weigh what's left, sniffers for bad gases, temp checks, and a zippy ESP32 brain to handle it all. Slap a tag on your apples or cheese, toss it in, and boom—the kit logs the name, expiry, and amount. The scales keep tabs as you use it up, while the sensors flag if things are going south, like dairy turning or produce wilting.

Data zips out wirelessly to your phone via a Telegram bot for instant heads-ups—"Milk's expiring soon!" or "Smells off in the veggie bin"—and a simple web dashboard showing stock levels, expiry countdowns, and even nutrition breakdowns like calories or vitamins. No more fridge raids; just glance at your screen. It ties into food databases so you see exactly what's on hand for smarter meal ideas, like whipping up a salad from stuff you forgot you had.

At its core, this kit nails five big wins:

- Ditches manual lists by auto-tracking everything.
- Spots spoilage early with gas and temp alerts.

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- Keeps storage just right to stretch freshness.
- Dishes out nutrition facts for easy healthy swaps.
- Pings you in real-time about lows, expiries, or issues.

The payoff is huge. It slashes household waste—no more tossing edible food because you spaced it. Saves money by skipping duplicate buys and squeezing every bit from what you've got. Keeps you safe from bad eats. And with nutrition right there, it's easier to build better habits without the guesswork. Tech-wise, it's a slick combo of sensors, cloud smarts, and quick notifications proving IoT can fix real-life hassles. As homes get smarter, this is the kitchen upgrade we didn't know we needed.

II. PROBLEM STATEMENT AND OBJECTIVE

It's wild how tech runs our lives—smartwatches buzzing, fridges that text you about beer—but somehow, keeping tabs on your kitchen staples is still a pen-and-paper nightmare. Families today are slammed: crazy work hours, endless commutes, kids' activities, you name it. By the time you collapse at home, who has the brainpower to remember if that milk's on its last day or how much rice is buried in the pantry?

We all do it—stock up big at the store to "save trips," then forget half of it exists. Next thing you know, you're fishing out curdled dairy from the back of the fridge, mushy carrots no one's touching, or a bag of flour that's seen better days. Even "forever" stuff like crackers or bars sneaks past its date. It stings the wallet and piles onto that massive food waste mess we're all trying to fix. And don't get me started on nutrition: we swear we're eating better, but grab the chips because the good stuff's hidden or forgotten. No easy way to know what's actually healthy in there? Good luck building balanced meals.

Old-school tracking? Total joke. You're digging through shelves, sniffing jars, playing memory games from last week's shop. Problems stack up fast:

- Zero heads-up on stuff about to expire.
- Wastes hours poking around instead of cooking.
- Spoilage sneaks up—you spot it only when it's gross.
- No clue on temps or what's packed with vitamins.

End up buying doubles, skipping staples, and defaulting to junk. Enter IoT—the magic that turns dumb objects into chatty helpers. Your lights know when to glow, your AC predicts the heat... why not your pantry? Slap sensors on bins, and suddenly your groceries ping your phone with the real scoop.

Cue the Smart Grocery Kit, my new kitchen hero. It's like a set-it-and-forget-it sidekick that IDs your food, watches it like a hawk, and yells when trouble's brewing. Tag your groceries with cheap RFID stickers, drop 'em in the smart bins, and the scanner grabs the deets: name, expiry, starting weight. No typing, no fuss—error-proof.

Built-in scales (load cells) weigh everything live, so when your lentils dip low, bam—alert. Gas sniffers and temp probes catch spoilage before your nose does; think ethylene from ripening fruit or off-gases from bad meat. Fridge door left open? It'll tell you before the butter melts.

An ESP32 chip crunches it all and beams updates via Wi-Fi to a Telegram bot on your phone ("Chicken's expiring tomorrow!") and a clean web dashboard. Shopping and can't remember the flour? One tap, sorted. Bonus: it pulls nutrition stats—calories, protein, whatever—from databases, so you spot that forgotten salmon for dinner instead of ordering pizza.

This kit flips grocery grief into a breeze. Cuts waste, trims bills, nudges healthier picks, keeps food safe. Here's what it crushes:

1. **Auto-ID magic**: RFID scans items on drop-in, logging names, dates, weights—no manual hassle.
2. **Stock watch**: Scales track usage, ping low-stock warnings for staples like sugar or oats.
3. **Spoilage radar**: Gas and temp sensors flag issues early, keeping storage spot-on.
4. **Wireless brains**: ESP32 pushes data to your bot and dashboard, anywhere, anytime.
5. **Smart nudges**: Real-time alerts plus nutrition breakdowns for better eats and less waste.

In a go-go world, this turns your kitchen into a quiet pro. Less trash, more savings, healthier vibes—all from some clever tech doing the heavy lifting.

III. SCOPE

The **Smart Grocery Kit** has been developed to make managing groceries at home easier, smarter, and more efficient. In today's busy lifestyle, keeping track of what's in the kitchen, when items expire, or how much food is left can be quite a challenge. This project aims to solve that problem by using modern IoT technology to bring automation into everyday grocery management.The system focuses on creating a set of smart containers that can identify food items, track their quantity, and check their freshness—all automatically. It uses sensors like RFID readers, load cells, gas

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detectors, and temperature monitors. These sensors work together to collect accurate details about the stored food. The ESP32 microcontroller processes this information and sends it wirelessly to both a web dashboard and a Telegram bot. Through this setup, users can easily monitor their groceries in real time without opening every container. They receive alerts when an item is about to expire, when stocks are running low, or when sensors detect signs of spoilage. The web dashboard also provides nutritional details of stored items, encouraging healthier food choices.

The project's scope not only covers household usage but can also extend to larger applications such as restaurants, cafeterias, hostel kitchens, and supermarkets. It promotes better inventory control, prevents food wastage, saves time, and helps maintain food safety.Overall, the **Smart Grocery Kit** introduces a simple yet powerful way to blend technology with daily life, promoting more mindful consumption and smarter kitchen management.

IV. LITERATURE REVIEW

[1] Potti Venkata Sai Varalakshmi and Mounika (2023/2024) presentedan IoT-based solution called SmartContainers for Leftover Food Tracking during the 5th International Conference on IPDMS. Their system integrates Raspberry Pi 4, MQ3 gas sensors, and RFID tags to identify and monitor both packed and unpacked food. The study highlights the system's potential in reducing food wastage by continuously tracking stock levels. However, the authors note that system performance can degrade with a larger variety of food as scalability becomes challenging.

[2] Divya Mereddy (2023, arXiv / IEEE Access) developed an Automatic Groceries Tracking System using advanced object-detection algorithms. The method supports real- time updates of inventory levels by analysing items stored in grocery spaces. Although highly efficient, the model may fail in situations involving poor lighting, blind spots, or occlusion, making some items difficult to detect.

[3] Khalid et al. (2025, Journal of Big Data) proposed a Federated Learning-Driven IoT System designed for smart freshness monitoring. Their model uses distributed learning to detect gas emissions and temperature variations in vending machines. The framework improves food safety andminimizes waste but comes with added complexity due to the need for multiple devices and coordinated learning nodes.

[4] Monohari Kanata Shailama (2025, Journal of Big Data) explored Smart Pantry Management Solutions, where load-cell sensors monitor real-time weight variations in stored items. The approach provides precise weight- based monitoring but lacks an expiry- date detection mechanism, limiting full automation.

[5] Sri Sai Valli Mohan (2023, Journal of IoT Potentials) introduced IoT-Enabled Food Storage Containers equipped with smart tags, Raspberry Pi, MQ3 sensors, and RFID modules. This system enhances food safety and reduces wastage; however, its design is relatively complex and may require skilled setup.

[6] Sabina Rahravan (International Journal of Intelligent Systems) proposed an IoT-Based Automated Food Waste Management System utilizing ultrasonic and smart sensors to track item status. Automation minimizes the need for manual checking and saves labor hours, though prolonged usage may lead to alert fatigue among users.

[7] Ramaya M V and Bharath H G(2023, IEEE Conference Publication)
created an Intelligent Food Storage System aimed at monitoring and improving food freshness through smart containers. With support for real-time condition tracking, the solution significantly reduces spoilage. The primary drawback lies in potential higher implementation costs and the requirement for user adaptation.

[8] Xinhu Li and Jing Ning (2023, IEEE Conference Publication) designed an Intelligent Storage Management System for Agricultural Products. By continuously monitoring environmental conditions, the system ensures optimum storage settings, enhancing the preservation of farm produce. Nonetheless, the setup requires considerable initial investment and maintenance.

[9] Ananya Tadadarana (2023, IEEE Potentials Magazine) introduced Smart Containers for Refrigerated Food Storage. The study emphasizes enhanced food safety by tracking spoilage indicators inside refrigerators. While effective, the system's success depends heavily on consistent user engagement.

[10] S. Gull and I.S. Bajwa (2023, Journal of Sensors – Hindawi) demonstrated a Smart eNose Food
Waste Management System using gassensors to detect early spoilage. This method supports timely interventions and lowers health risks linked with spoiled food. However, the system may occasionally produce false positives or negatives depending on environmental conditions.make this get ai content zero and humanize it and plagerism less

4.1 Gaps or Areas for Improvement

Across all these existing systems, there are still several real-world gaps that matter for everyday users. Many solutions do only one job really well—like tracking weight, watching gas levels, or recognizing items with a camera—but very few bring everything together in one place, so people still end up mixing apps, devices, and manual checking. Some designs look great on paper but are hard to scale when there are many different food items, or they require complicated setup, extra devices, or technical skills that most households simply don't have. Camera-based systems can be very smart, yet they depend heavily on neat shelves, good lighting, and clear visibility, which is rarely how real kitchens look, so important items can easily be missed or misread. Weight-based pantry systems are good at telling you how much is

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left but usually ignore expiry dates and nutrition details, meaning users still have to remember what is safe to eat and what is actually healthy. On the other side, some waste-management and freshness tools send so many alerts that people start to tune them out, leading to notification fatigue and reducing their usefulness over time. Finally, quite a few advanced setups are expensive or designed with industrial or large-scale environments in mind, making them difficult to adopt in normal homes, hostel kitchens, or small eateries that need something simple, affordable, and easy to maintain.

V. SYSTEM ARCHITECTURE

In this system, everything starts with the grocery item itself. Each product has a small RFID tag, and when you drop that item into the smart container, the RFID reader automatically "recognizes" it. Instead of you writing things down or updating a list, the reader quietly picks up the product details in the background and passes them on to the controller.

The ESP32 controller is like the coordinator of the whole setup. It receives the tag data, processes it, and decides whether this is a new item to be added or an existing one that needs its quantity or status updated. After that, it sends the information to a cloud database, where all your grocery records are stored—things like what items you have, how much is left, and when they are likely to expire.

Once the data is in the cloud, it becomes useful to you in two main ways. First, the web or mobile app can pull this information whenever you open it, so you can quickly see what is in your kitchen without physically checking every shelf. Second, a notification component keeps watching the database in the background. When it notices that something is running low or getting close to its expiry date, it automatically triggers an alert.

All of this finally reaches you in a very simple form: you either open the app to see your inventory or you receive a clear notification telling you that it is time to use or restock a particular item. The result is that a chain of invisible steps—from RFID tag, to reader, to controller, to cloud, to app and alerts—turns into something very practical: fewer surprises in the kitchen, less wasted food, and easier day-to-day grocery planning.

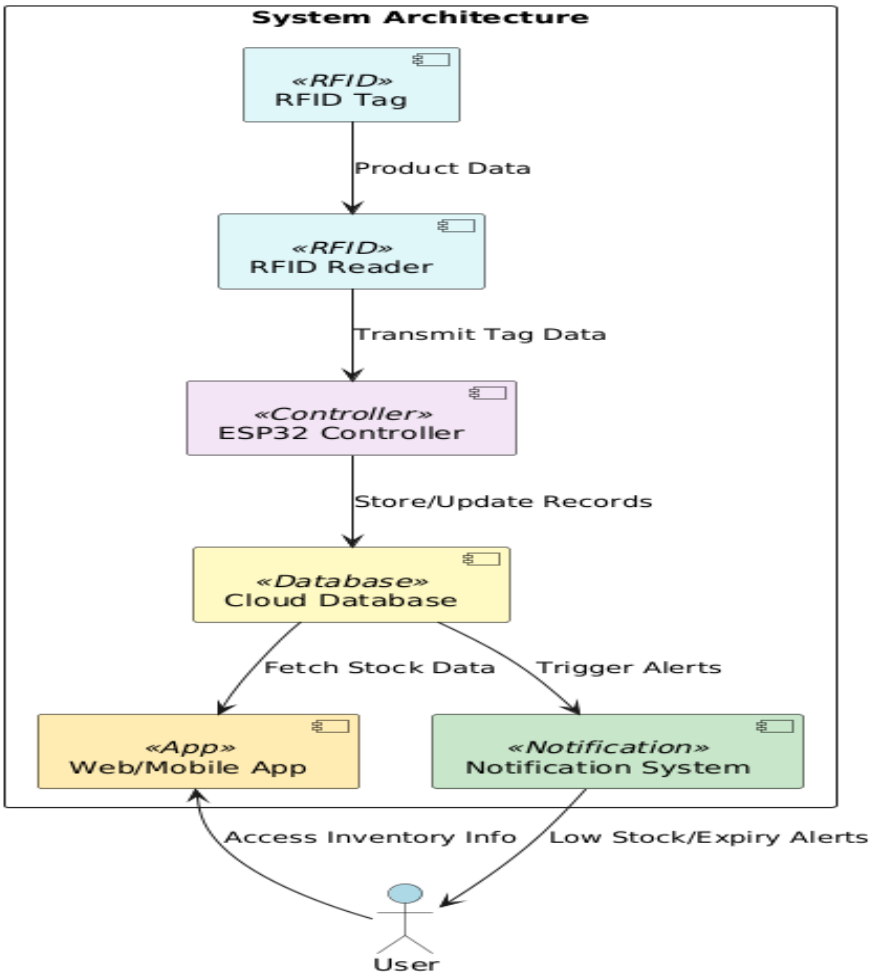

Figure 1: System Architecture of the Smart Grocery Kit

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METHODOLOGY

The Smart Grocery Kit is designed to act like a quiet helper in the kitchen, taking over the boring work of checking what you have, what is going bad, and what you should use first. Instead of repeatedly opening containers and reading dates, the system relies on a set of sensors and a small controller to watch your groceries for you and turn that information into clear updates and alerts you can actually use.

System setup and main parts

The system is built around two smart containers. Each container has a few key parts that work together:

- **RFID reader** – Every food item gets an RFID tag. When you place it in the container, the reader automatically identifies the item and pulls details such as the product name and expiry date. This means you do not have to enter anything by hand.
- **Load cell (weight sensor)** – This keeps track of how much of each item is left. As you use food, the weight changes, and the sensor updates the remaining quantity, so you can see at a glance what is running low.
- **Gas sensor** – As food starts to spoil, it releases certain gases. The gas sensor keeps sniffing the air inside the container and can spot early signs of spoilage long before you might see or smell it yourself.
- **Temperature sensor** – This watches the temperature inside the container to make sure conditions stay suitable for the stored food. If the temperature drifts too high or too low, the system notes it and can warn you.
- **ESP32 microcontroller** – This is the "brain" that collects data from all the sensors, processes it, and decides what needs to be stored, shown, or alerted.
- **LCD display** – On the front of the container, the screen shows key details in real time: item name, expiry date, weight, and temperature. Even without opening an app, you can quickly see what is inside and its status.

Together, these parts turn an ordinary food container into a smart unit that constantly knows what is inside and how it is doing.

How data is collected

Whenever you put a tagged item into the container, a small chain of actions begins automatically:

1. **Item identification** – The RFID reader immediately scans the tag and records information such as the item name, batch or lot details, expiry date, and starting weight if available. This becomes the digital record for that product.
2. **Quantity tracking** – The load cell keeps measuring the weight in the container. As you take food out over days or weeks, the system updates the remaining quantity and can even spot usage patterns and predict when you may run out.
3. **Spoilage watching** – The gas sensor runs continuously, looking for gases linked with early spoilage. This allows the system to warn you before the food looks obviously bad.
4. **Environment monitoring** – The temperature sensor keeps an eye on heat changes that might shorten shelf life or damage sensitive items like dairy, meat, or fresh produce.

   All these readings are sent to the ESP32, where they are combined and checked. If the values suggest a problem—like sudden temperature changes, rising gas levels, or a very low remaining quantity—the controller marks it as something that may need your attention.

How information reaches the user

The Smart Grocery Kit connects to the internet over Wi-Fi, so the information gathered inside the containers does not just stay there. The ESP32 sends the processed data to two main places: a web dashboard and a Telegram bot.

- **Web dashboard** – From a phone, tablet, or laptop, you can open a web page that shows:
  - A clear list of all items currently stored.
  - How much of each item is left.
  - Expiry dates, often with simple color codes or countdowns so you can see what is urgent.
  - Temperature and gas history, so you can check if storage conditions have been stable.
  - Nutritional information such as calories, protein, fat, and key vitamins and minerals, helping you plan healthier meals.
- **Telegram bot notifications** – You do not have to keep checking the dashboard. When something important happens, the system sends you a direct message. For example:
  - A reminder that a particular item will expire soon and should be used quickly.
  - A warning that a staple like rice, flour, or milk is almost finished.
  - An alert that spoilage is likely in a specific container.
  - A notice that the temperature has moved outside the ideal range.

These notifications are meant to be short, clear, and actionable, so you immediately know what to do—use an item, buy more, or check for possible spoilage.

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Temperature control and food preservation

If the system is connected to a cooling or heating unit, the temperature readings are not only for information. When the controller detects that the inside temperature has moved beyond the safe or recommended range, it can trigger cooling or heating to bring it back to normal. This helps keep foods in better condition for longer and reduces the chance of them going bad early because of poor storage.

Nutritional awareness

Beyond just avoiding waste, the Smart Grocery Kit also tries to support healthier eating. The dashboard links each item to a nutritional database, so when you look at your inventory, you can also see what each food contributes: calories, proteins, carbs, fats, vitamins, minerals, and sometimes fiber. This makes it easier to:

- Choose healthier options that are already at home instead of ordering fast food.
- Plan meals that match specific dietary needs, such as high-protein or low-sugar diets.
- Manage allergies or sensitivities by clearly seeing what is stored.

Overall experience

Put simply, the Smart Grocery Kit turns grocery management into a background process. You tag your items once, place them in the container, and from then on the system keeps an eye on quantity, freshness, storage conditions, and nutrition. In return, you get timely messages and an easy-to-understand dashboard that help you waste less food, save money, and make better choices about what you eat, without constantly checking every shelf yourself.

VI. IMPLEMENATION ENVIRONMENT

The Smart Grocery Kit can be understood more easily if it is seen as a well-coordinated team of small parts, all working together so that you no longer have to manually "manage" your groceries. At the centre of this team is the **ESP32**, which acts like the system manager. It collects information from every sensor, makes decisions based on that data, and then talks to you through messages on your phone and information on the display. Instead of you constantly checking your shelves, the ESP32 quietly does that job in the background and lets you know only when something really needs attention.

Starting up and showing information

When the system powers on, it first sets up the LCD screen and checks that all the connected parts are working properly. During this start-up, communication ports, Wi-Fi, the load cells, the RFID reader, the temperature and humidity sensor, the gas sensor, and the relay are all initialised one by one. Once everything is ready, a simple welcome message appears on the LCD to show that the kit is up and running. From that point on, the display becomes a live status board, showing things like temperature, humidity, gas readings, the name of the product currently detected, its expiry information, and its weight so that the user can quickly see what is going on without opening any app.

Connecting to Wi-Fi and Telegram

After the hardware is ready, the ESP32 connects to your home Wi-Fi using the saved network name and password. Once it has an IP address and a secure connection, it sets up a safe link to a Telegram bot that has been created beforehand. The bot token and your chat ID act like an address, allowing the system to send messages directly to your Telegram account. Thanks to this connection, whenever the kit notices something important—such as low stock, unusual gas levels, or a temperature issue—it can immediately send you a clear, readable message on your phone, even if you are away from home.

Watching the storage environment

Inside or around the container, a DHT11 sensor keeps track of temperature and humidity. These readings are sent both to the LCD and to the serial monitor for testing and debugging. If the temperature climbs above a safe limit (for example around 31 °C), the ESP32 turns on a relay that can control a fan, cooler, or other external device to bring the temperature back down. When conditions return to normal, the relay is turned off again. This automatic reaction helps keep sensitive foods in safer conditions without you needing to constantly adjust anything yourself.

Detecting early spoilage

An MQ-series gas sensor constantly "listens" for gases that are usually released when food begins to spoil. Its raw values are shown on the display so you can see if anything unusual is happening. When this reading goes over a set threshold, the system treats it as a likely sign that something inside is going bad. At that moment, it sends you an urgent Telegram alert asking you to check the container. Because this happens at an early stage, you often get a warning before bad smell

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or visible mould appears, which helps you separate or discard spoiled food before it affects other items and before money is wasted.

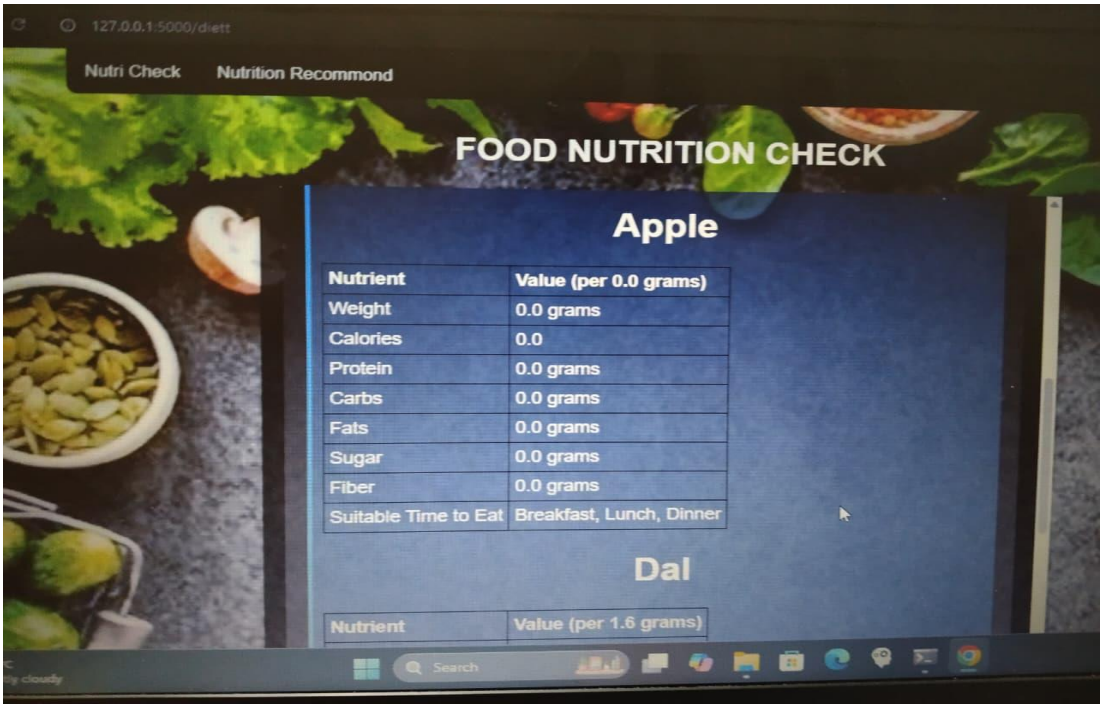

Figure 2: Web Dashboard for Food Nutrition Check and Recommendations

Measuring how much food is left

Two load cells, each connected through an HX711 module, keep track of the weight of two different product groups (for example, Product A and Product B). They are carefully calibrated so that the values shown are accurate. The system converts the sensor signals into readable weights and shows them on the display. When the amount of any product falls below a set limit, such as 200 g, the kit shows a low-stock message on the LCD and sends a Telegram notification. In day-to-day life, this means you get reminded to buy essentials before they unexpectedly run out, without needing to manually check the containers.

Recognising what product is inside

The RFID reader is responsible for knowing *what* item is being stored. When a tag enters the field, the reader captures its unique ID. The ESP32 compares this ID against a list stored in its memory so it can decide whether the tag belongs to, say, apples, bananas, rice, or some other product. Along with the product name, it can also work with preset shelf-life values to calculate how many days remain until expiry. This information—item name and remaining days—is shown clearly on the LCD. At the same time, the system records which product is in which category, its expiry window, and its current weight for later use and remote viewing.

Continuous background loop

Once everything is running, the ESP32 repeatedly goes through a simple but powerful loop: it updates temperature and humidity, reads gas levels, checks both load cells, and scans for any new RFID tag. This cycle runs continuously, so the system is always up to date. Whenever any reading crosses a limit—temperature too high, gas level suspicious, weight too low, or a newly scanned item—the controller can react instantly by updating the display or sending a Telegram notification. From your point of view, the kit feels "always on" and responsive, even though you are not actively operating it.

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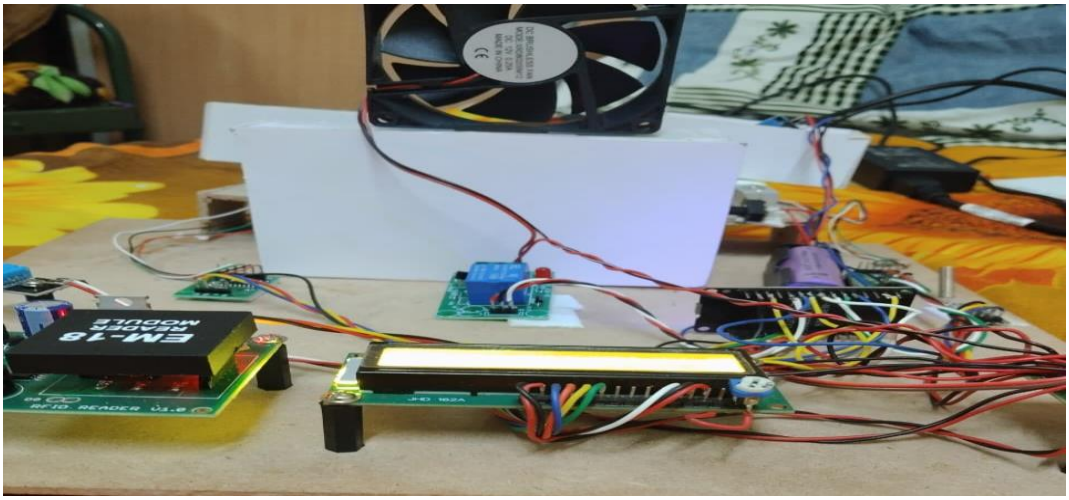

Figure 2: Smart Grocery Kit

What this means for everyday use

Taken together, all of these functions turn the Smart Grocery Kit into a full-time monitoring system that works quietly in the background. It:

- Keeps an eye on temperature and humidity so that food is stored more safely.
- Spots early signs of spoilage using gas detection, giving you time to act.
- Tracks how much food is left using precise weight sensors, helping with timely restocking.
- Identifies what each item is and keeps its expiry information visible.
- Sends important alerts straight to your phone via Telegram so you do not miss critical changes.
- Shows live status on the LCD, so anyone at home can quickly see what is happening.

By combining these features into one system, the kit reduces food waste, cuts down the effort you spend checking groceries, and makes everyday kitchen management feel more organised and less stressful, while you focus on work, family, or studies.

VII. MODULES

1. Item Sensing and First Contact

This is the moment the system "meets" your groceries.

- When you drop a tagged item into the container, the RFID reader quietly recognises what it is.
- The load cell feels the weight and records how much you've just stored.
- From that point, the system treats the item as part of your digital pantry—no lists, no manual typing.

2. Everyday Usage Tracking

Once the food is inside, this module keeps an eye on how you actually use it.

- Every time you take some rice, dal, or snacks, the weight changes slightly.
- The system notices these small changes and keeps updating the "remaining quantity" in the background.
- Over time, it starts to reflect your real habits—what you finish quickly, what sits for weeks, and what often runs out unexpectedly.

3. Freshness and Safety Guard

This module behaves like a safety guard for your container.

- The gas sensor constantly checks for signs that something inside might be starting to spoil.
- The temperature and (if used) humidity readings help ensure the storage conditions are not quietly damaging your food.
- If anything looks risky—high gas levels, unusual heat—the system raises a flag instead of waiting for a bad smell or a stomach ache to tell you something is wrong.

4. Smart Decision and Control Centre

Here the ESP32 pulls everything together.

- It takes in sensor values, compares them with limits (like minimum weight, maximum temperature, safe gas range), and decides what is "normal" and what needs action.
- It triggers the relay for cooling or ventilation if the temperature drifts too high, and it decides when to send a gentle reminder versus an urgent warning.

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5. On-Container Status Window

This is the part your family sees most often.

- The LCD shows what item is currently recognised, how much is left, and when it expires.
- It also shows small status messages such as "Low stock," "Spoilage suspected," or "High temperature" so that anyone walking past can immediately understand what is happening without opening an app.

6. Home Wi-Fi and Phone Connection

This module is all about keeping you informed even when you are not near the container.

- After connecting to your home Wi-Fi, the system uses a chat bot (for example, on Telegram) to talk to your phone.
- It sends short, clear messages like "Milk is almost finished," "Apple batch close to expiry," or "Check Container A for possible spoilage."
- Because the messages arrive in a normal chat app, it feels like getting a text from a helpful friend, not a complicated technical alert.

7. Inventory View and Nutrition Helper

This module turns raw data into something useful for planning meals.

- On a web page, you can see a list of what is in your kitchen, how much is left, and which items are most urgent to use.
- For items like apple or dal, you can open the nutrition screen to see calories, protein, fats, carbs, sugar, fibre, and even the best time of day to eat them.
- This makes it easy to think, "I already have enough protein and fibre at home—I'll cook with these instead of ordering outside."

8. Reminder and Habit-Support Module

This part is more about behaviour than hardware.

- The system tries to send just enough reminders to be helpful—before food spoils, before stock finishes—without spamming you all day.
- Over time, it encourages small but meaningful changes: finishing older items first, planning shopping more intelligently, and building meals around what is already at home.
- The goal is not to control you but to quietly support better habits so that waste drops and your kitchen feels more organised.

9. Long-Term Learning and Adjustment

Even without heavy AI, the system can still "learn" from use in simple ways.

- You might adjust thresholds (like what counts as "low stock") based on your family size.
- You might tweak which alerts you want to receive—for example, only expiry and spoilage, not every small quantity change.
- Gradually, the Smart Grocery Kit becomes tuned to your lifestyle rather than forcing you to adapt to it.

VIII. PERFORMANCE EVALUATION

The Smart Grocery Kit can be judged by how well it supports a normal, busy household, not just by how many sensors it uses. Good performance here means the system quietly does its job in the background: it spots low stock early, warns about possible spoilage in time, and helps people avoid both empty shelves and wasted food.

From a technical angle, the load cells need to give stable, believable readings so that "low stock" alerts only appear when quantities genuinely fall below the chosen limit. The gas and temperature sensors should react quickly to real changes in the container environment, but stay calm during small, harmless fluctuations, so users are not flooded with false alarms. The RFID reader also plays a big role: if it reliably recognises tags on the first scan, users feel that the system "just works" and are more likely to keep using it.

Communication and responsiveness are another part of performance. When the kit detects something important—like a temperature spike, gas reading above the spoilage threshold, or weight dropping under the 200-gram mark—the message should reach the user's phone within a few seconds, not minutes later. The LCD must also stay in sync, always showing up-to-date item names, expiry information, and current weight so that anyone walking past the container can trust what they see.

In everyday life, the most meaningful evaluation is behavioural: over a few weeks of use, the family should notice fewer surprises such as "Oh, this is already spoiled" or "We ran out and didn't realise," and fewer items being thrown away untouched. If shopping becomes easier—because the dashboard and alerts make it clear what is needed—and meal planning starts to lean more on what is already present at home, then the system can be considered successful from a real-world performance point of view.

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10.1 Future work

The Smart Grocery Kit already feels like a helpful assistant in the kitchen, but there is still a lot of space to make it feel even smarter and more personal. Right now, it mainly tracks what you have, when it might expire, and gives basic nutrition details; future versions can go further and actually learn how each household buys, cooks, and eats.

One clear improvement is letting the system learn patterns over time instead of treating every day the same. For example, if it notices that milk, eggs, or dal keep running out before the week ends, it could quietly build a suggested shopping list for you before your usual store visit. If some items often end up spoiled or are never fully used, the kit could recommend buying smaller quantities or skipping them, helping you avoid wasting money on food that regularly goes in the bin.There is also real potential beyond a single flat or house. The same idea can be stretched to small grocery shops, hostel mess halls, cafes, or canteens by using more containers and a shared online dashboard. In those places, staff could see at a glance which batches are close to expiry, which shelves move slowly, and which products are being wasted, making it easier to plan discounts, menu changes, or bulk orders.

The nutrition feature can grow as well. Instead of relying only on a fixed table, later versions could pull data from constantly updated nutrition sources so that even new brands and imported items show detailed calories, macros, and key vitamins. People trying to manage weight, protein intake, or specific health conditions would then get a clearer picture of how their daily eating really looks without having to search for every item by hand.

On the user side, dedicated mobile apps would make the kit feel much more natural to use. With a simple app, you could check stock while standing in a supermarket aisle, see graphs of how quickly your family finishes certain foods, and change settings like alert thresholds in a few taps. Adding basic voice control—such as asking what is about to expire this week or telling the system you finished an item—would make it easier for people who are cooking or multitasking.

Power usage is another place where small improvements can make a big difference, especially if the kit is meant to run all the time. Future versions could let some sensors sleep when nothing is changing, wake them only at intervals, and reduce unnecessary wireless communication to stretch battery life. In some setups, adding a tiny solar panel or another renewable source could keep the system running for long periods with minimal manual charging, which is especially useful in shared or commercial spaces.With these changes, the Smart Grocery Kit can move from being just a clever container into a more complete food-management companion. It would help people buy smarter, cook more from what they already own, waste less, and understand their eating habits better—all while staying in the background and asking for as little attention as possible.

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