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An intelligent IoT-based system for monitoring, managing, and redistributing dairy products

[1]Roaa Habes Ibrahem Magableh
Department of Industrial Engineering-Yarmouk University
Mahis, Jordan

[2]karam Ahmad Bani Awwad
Department of Industrial Engineering-Yarmouk University
Irbid, Jordan

[3*]Ghazi M. Magableh
Department of Industrial Engineering-Yarmouk University
Irbid, Jordan

Abstract—*Due to their limited shelf life, dairy products result in substantial waste. The goal of this study is to develop an integrated smart system for factory warehouses and retail freezers utilizing Internet of Things (IoT) technologies. It will use sophisticated sensors and vision systems to read QR codes, gathering manufacturing and expiration date data for cloud processing, and use QR code technology to store important product information. By enabling wise decision-making prior to product expiration and categorizing goods according to perishability via a smart dashboard, the technology encourages proactive control for factories. Overall, this study represents a qualitative change in intelligent inventory management and promotes sustainability in the food business by cutting waste and improving production efficiency.*

Keywords—IOT, QR code, Intelligent system, dairyproducts, smart fridge, milk supply chain

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I. INTRODUCTION

The food industry and dairy products have complex logistics management issues in the area of inventory control because of the perishability of the product. The conventional approach to the storage of the product by the retailers still depends on the periodic checking of the expiry dates and the stock levels. This has caused issues in the management of the inventory. The development of the Internet of Things (IoT) technologies has been rapid and continuous. However, the majority of the technologies developed in this area are only useful in the home and do not have an overall framework to connect the retail and production sites in order to have a continuous data flow.

The issue, in this case, is the lack of a proper digital tracking system that connects the display refrigerators in the retail stores to the factory production systems. This results in poor predictions of demands and inefficient management of returns before spoilage. The main questions of this research are as follows: How can the integration of IoT and QR code technologies help to create smart display refrigerators that can bridge the information gap between producers and consumers?

To what extent does early warning help to improve redistribution strategies and reduce food wastage?

As a result, the objective of this study was to create a smart system that can monitor dairy products in real time and create a digital communication network that connects the retail stores and factory production systems. The aim of this study was to create a technological solution that can guarantee continuous supply, improve accuracy in automated inventory, enhance reuse capabilities, and incorporate sustainability principles before reaching the spoilage point

II. Literature Review

Phase I:Smart Monitoring and Inventory Management Systems

Recently there has seen increased research activities aimed at developing food inventory management systems to reduce food waste in households. For instance, Vadilillah et al. (2026) proposed a model for the development of an Android-based smart application that monitors food expiration dates. Although the system is effective in promoting consumer awareness, the system has limitations in that the user is required to manually input the data, which is not effective in real-time data accuracy. This gives room for the integration of automated systems using barcode and RFID technologies

Phase II: Environmental Tracking and Monitoring Technologies in Supply Chains

Digital tracking technologies form a solid basis for the transition to smart supply chains. In this context, a study by Zhou et al. (2025) examined the evolution of validity tracking tools from traditional barcodes, QR codes, and thermal time indicators (TTI).

Yusoff et al. (2021) emphasized the role of the Green Internet of Things (IoT) in the quality monitoring of perishable products, where the integration of sensors and tracking tools helps reduce environmental and economic damage. In addition, Jachimczyk et al. (2021) examined the issue of data transparency in dairy supply chains (DSCs), where the integration of all stakeholders in terms of IoT tools helps increase the efficiency of planning and reduce spoilage

Phase III: Innovation in Smart Packaging and Real-Time Spoilage Sensors

Current research has gone beyond simply monitoring external sources (smart packaging) that interact with food. A study by Sobhan et al. (2025) showed that biosensors in food packaging play an important role in detecting gases that are emitted during spoilage at the time of spoilage. Another study by Rosli et al. (2026) further emphasized this trend with the introduction of Novair technology that utilizes gas sensors to alert users in real time at the time of deterioration and spoilage. A study by Priyadarshini et al. (2026) also showed packaging innovation through the incorporation of nanotechnology to extend shelf life, and it is suggested that an integral part of this is combining good packaging with the technology that a monitoring system offer..

III. Research Methodology

The proposed research framework seeks to develop a hybrid system that incorporates the technologies of physical perception and data analysis in such a way that the process is highly efficient in the management of dairy product inventories. The methodology in this regard starts with the collection of data in real time by installing an integrated optical and weight sensor system in the storage units.

- Each product is provided with a QR code that holds precise data such as the product type, production dates, and expiry dates. OV2640 vision sensors, with the assistance of ESP32-CAM controllers, are used to read the data automatically.
- This process is highly efficient in the management of data in that it is completely automated and free of any human error. The system also helps in the improvement of the monitoring process with the integration of load cells that are placed a*t the underside of the shelves.*
- The load cells calculate the total weight of the products and automatically update the number of products that are available. This process is highly efficient in that it is carried out without any human intervention. In the process of updating the number of products that are available in the storage units, the temperature and humidity levels are constantly monitored with the integration of SHT3x and DHT22 sensors. The data collected in the process is transmitted via an IoT gateway with the assistance of Wi-Fi protocolsUnits

The methodology then proceeds to the decision-making phase, where the system actively sends hierarchical alerts to the store owner and manufacturer. The alerts start several days before expiration dates, followed by more urgent alerts during critical periods or environmental conditions. Using direct digital connectivity, manufacturers and management make smart logistical decisions prior to spoilage, which may include discounting prices for consumption by consumers or diverting products for other manufacturing uses, such as fertilizers. Based on the above data, the business model is transformed from the traditional system to a system using actual demand and data stored in the cloud, which is more sustainable for the supply chain and contributes to the “zero waste” initiative in the food industry sector.

IV. System Design

The system includes an integrated infrastructure that is intended to digitize the process of dairy inventory management through the use of processes like real-time monitoring and networking. It also includes the integration of hardware with cloud solutions to ensure the accuracy and flow of the data. This is accomplished through the following principles:

A. Detailed System Architecture

Perception Layer: The physical part of the system that houses the sensors and computer vision cameras for collecting information from the surrounding environment and products.

Network Layer: Responsible for transmitting the information collected through Wi-Fi technology for efficient information processing centers.

Application Layer: The intelligent control interface (dashboard) that converts the processed information from the raw data into visual information for decision-making.

B. Advanced Barcode System

Two-dimensional (2D Data Matrix & QR Code) codes were selected as an advanced alternative to conventional systems due to their capacity to store essential information such as batch numbers, production dates, and expiration dates in limited spaces on product packaging. This technology is recognized by its reliability in reading information in high humidity environments, such as inside refrigerators, with the capacity to withstand up to 25% scratches without any loss of data, thus making it an economical solution for industrial environments.

C. Integrated Sensing Units

The system utilizes hybrid sensing for comprehensive monitoring of the product and its surrounding environment. The system uses the following sensors for monitoring:

- **Environmental Monitoring**: The system utilizes DHT22 or SHT3x sensors for precise monitoring of temperature and humidity levels, thereby maintaining products at hygienic conditions.
- **Quantity Monitoring (Load Cells):** Weight sensors are placed at the bottom of the shelves for monitoring weight. This enables the system to detect any shortage in products, thereby updating the inventory automatically.
- **Computer Vision Unit**: The system utilizes an OV2640 camera with an ESP32-CAM controller, acting as a vision sensor, for accurate monitoring of products using barcodes at low costs

V. Operational Workflow

As shown in Figure (1), the system works by scanning the items of products as they are received, thus recording their details in a database. Real-time monitoring of the environmental factors is maintained, with an instant notification system in place in case of any deviation from the ideal temperature. The system can calculate the reorder point using the weight data, thus automatically generating orders to the factory for restocking before the items get depleted. This design, therefore, facilitates a strategic shift from the conventional push system to the pull system through the use of IoT technologies

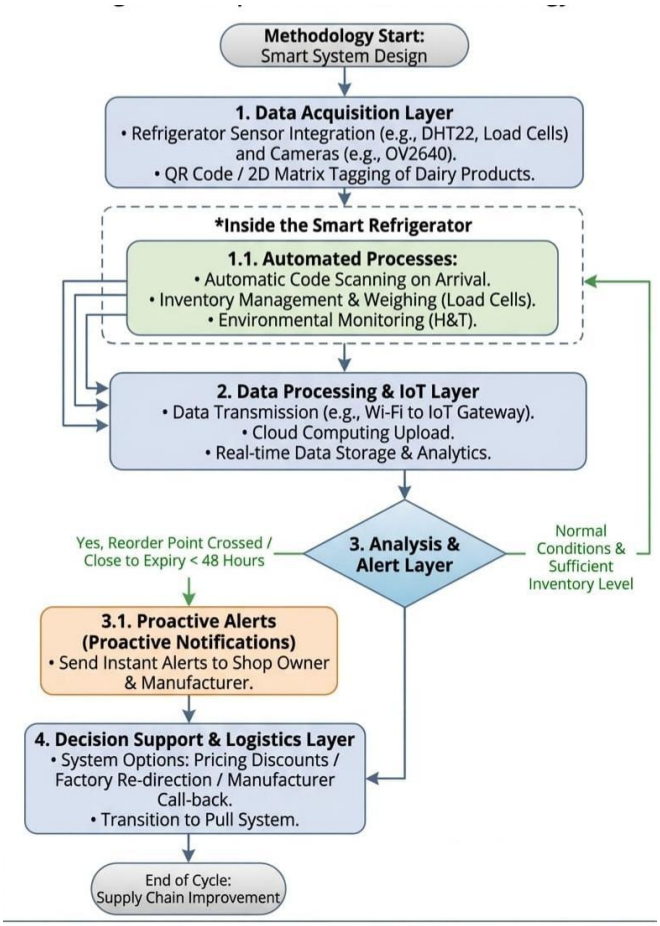

Figure 1: The flow of the system

VI. Discussion and Value Proposition

The proposed system promises a fundamental shift in the management of dairy supply chains, from conventional reactive approaches to smart, proactive approaches that prevent problems before they happen. By examining and analyzing the results of the system, the value added and expected can be examined along the following axes:

A. Operational Automation and Efficiency of Inventory Management

The proposed system helps achieve the full automation of inventory counting operations without any human intervention, resulting in a significant reduction of human error. With the integration of 2D Data Matrix and load cells, the system promises a high level of accuracy in traceability, not only in terms of the number of items but also in identifying items that are near expiration. This results in a strict adherence to the First-In, First-Out (FIFO) rule, which necessarily leads to a significant increase in the inventory turnover ratio and a reduction of waste.

B. Sustainability and Waste Mitigation

The system is also dealing with the problem of waste milk through the 'Zero Waste' concept. It also ensures an intelligent system of alerts that will be sent to the factory and the retailer 48 hours prior to the expiration date of the milk product, which will be helpful in taking preventative measures against the waste of milk products and their reuse in other manufacturing processes in the food industry.

C. .Data-Driven Decision Making

With the help of Big Data Analytics, the system is helpful in making decisions based on demand sensing. The system is changing the traditional supply chain system from a 'push system' to a 'pull system' with the help of IoT technology. The system is also helpful in generating significant economic benefits through reduced labor costs in the system

D. Challenges and Proposed Solutions

Although the system is effective in dealing with the problem of waste milk, there may be challenges in implementing the system in the business, which may include the initial cost of equipment and the requirement of an internet connection. To overcome these challenges, the research suggests the use of 'QR code' technology to reduce costs, which may also be helpful in storing data locally in case of internet failure and ensuring business continuity. The system of designing a structured system of logistics is also helpful in making the system more efficient.

VII.AN ARTIST'S RENDERING OF THE SYSTEM INSIDE A REFRIGERATOR

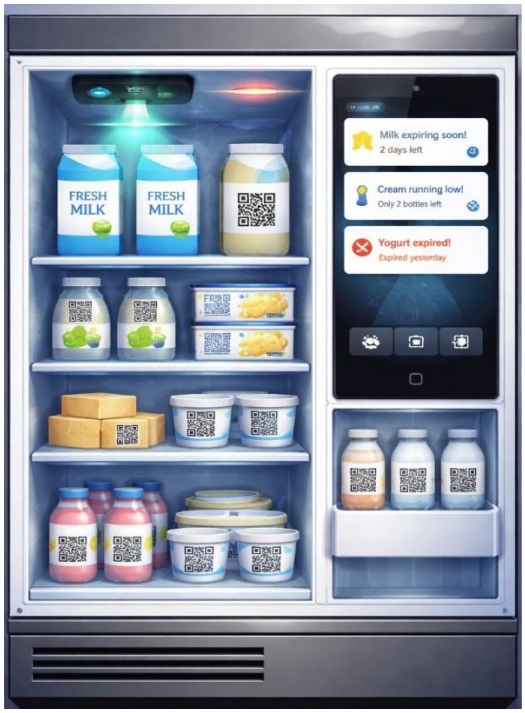

Figure (2) illustrates the system lookalike inside a refrigerator.

VIII. Implementation of an Intelligent Cognitive Platform for Supply Chain Sustainability and Waste Reduction

The proposed intelligent system is an advanced form of intelligent monitoring technology, known as a "Cognitive Autonomous Platform," combining IoT edge computing with real-time AI. It allows having data analytics capabilities which can be implemented at any stage of the supply chain, thus providing instant results in relation to all aspects of the "Triple Bottom Line" concept, including its theoretical and practical aspects.

It acts as a cloud-based "Proactive Decision Engine" analyzing large-scale data flows from smart sensors and internal barcode scanning cameras. The application of machine learning makes it possible to understand the patterns of consumers' dynamic behavior, seasonal changes in consumption as well as changes in the levels of sales and demand.

From the above analyses, the system has the capacity to proactively detect potential spoilage of the products in advance, predict the future demand of the products and recommend the best order quantity for reordering from suppliers in order to keep the inventory in balance and thus avoid shortages or overstocking. Furthermore, it generates alerts when there are any abnormal changes in the storage environment and recommends automated actions, such as organizing shelves according to the FEFO (First Expired, First Out) strategy or adopting flexible pricing models where dynamic prices are adjusted according to the quality of the products and the time left on the shelves in order to sell the products quickly.

The same digital integrated system allows data exchange in real-time with the distributors and manufacturers which helps speed up the reordering process and optimize the planning and production and thus eliminate the "Bullwhip Effect".

This paradigm shift has a direct effect on sustainability and minimization of the negative impact on the environment because even though the inclusion of sensors and cameras requires some extra direct use of energy, the Life Cycle Assessment (LCA) reveals that it has "a net-positive environmental impact." It is realized through minimizing emissions of methane (CH_4) and carbon dioxide (CO_2) which occur due to decomposition of organic materials, such as spoiled dairy goods, stored in landfills through smart atmospheric packaging (MAP).

In addition, the energy control mechanism changes to one called "Closed-Loop Energy Control," which is based on the true thermal mass measured for the shelves. In this way, there will be no operational wastage with regard to the main compressor, but the additional cost of installing these sensors will be balanced by reduced emissions from urgent transport and distribution. The financial implications of this include low-capex because of the availability of the affordable sensors and cameras, and OpEx efficiency. It converts environmental sustainability into a tool for achieving superior profits and a source of competitive advantage in the age of AI revolution.

IX. Conclusion

The present research proposes an innovative scientific solution to overcome the challenges of managing dairy product inventory, which is one of the most sensitive and one of the shortest-lived food products.

The system successfully connects the gap between retail stores and factories and transforms the supply chain from an error-prone manual inspection system to an intelligent system based on real-time data through the integration of Internet of Things (IoT) technologies and AI vision and QR code technologies.

Moreover, the proposed methodology proves that the complete automation of inventory processes and environmental monitoring (temperature and humidity) can significantly contribute to the achievement of the "zero waste" concept, as alerts can be sent in real-time, such as 48 hours prior to expiration dates.

The system not only contributes to the reduction of waste but also improves the efficiency of operations by reducing labor costs and inventory turnover, transforming the supply chain from a push system to a pull system based on real demand.

From an operational perspective, some challenges may appear in terms of technical constraints, such as the initial investment in equipment and the need to maintain connectivity in the network.

Alternative solutions have been proposed to overcome these challenges, such as edge computing, in order to maintain the continuity of operations.

Based on the aforementioned, the proposed solution is recommended to be extended to other highly sensitive food sectors.

The present research opens the door to the integration of machine learning models to more accurately predict consumption patterns and develop unified platforms to ensure the efficiency of food returns and recycling processes throughout the country.

REFRENCES

[1] K.S.Kanna1, R. Amudha2"Role of Digitalisation and Technology in DairySupply Chain Management "International Journal of Advanced Research in Computer and Communication Engineering .Vol. 11, Issue 1, January 2022. DOI: 10.17148/IJARCCE.2022.11142.

[2] Mr. Raghavendra Patil G E, Ms. Dhanusha I, Ms. Ranjitha Y, Ms. Sukeerthi K C, Ms. Himashree, 0, Smart Fridge, " International Journal of Engineering Research & Technology(IJERT) ICRTT – 2018 (Volume 06 – Issue 15),

[3] Zhou, X., Tang, J., Jacobs, T.L. and Saguy, I.S., 2025. Transforming food supply chains through digital tracking and monitoring technologies. Trends in Food Science & Technology, 163, p.105142.

[4] Ramundo, L., Taisch, M. and Terzi, S., 2016, September. State of the art of technology in the food sector value chain towards the IoT. In 2016 IEEE 2nd International Forum on Research and Technologies for Society and Industry Leveraging a better tomorrow (RTSI) (pp. 1-6). IEEE.

[5] Zainatul Yushaniza Mohamed Yusoff 12, Mohamad Khairi Ishak'• , Kamal Ali Alezabi' "The Role of RFID in Green IoT: A Survey on Technologies, Challenges and A Way Forward" Advances in Science, Technology and Engineering Systems Journal Vol. 6, No. 1. 17-35 (2021) Special Isue on Multidtewpiar; Serences and Einginerins

[6] Vadililah, F., Prayoga, D.A. and Maulana, M.A., 2026. Development of a Mobile Smart Fridge System for Intelligent Food Stock Monitoring and Management. International Journal of Computing Research (IJCR), 1(1).

[7] Jachimczyk, B., Tkaczyk, R., Piotrowski, T., Johansson, S. and Kulesza, W., 2021. IoT-based dairy supply chain-an ontological approach. Elektronika ir Elektrotechnika, 27(1), pp.71-83.

[8] Dr. Shweta Priyadarshini', Dr. Vidisha Mishra?, Dr. Kusum Kumari?, Dr. Sangeeta Rani" and Dr. Renu Kumari' Exploring The Latest Trends and Techniques" Addaiyan Journal of Arts, Humanities and Social Sciences, 2026; 8(1):pp.112-120