

# Intelligent Canteen Management Using Machine Learning for Real-Time Ordering and Sustainable Operations

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**Abstract**—Canteen management in colleges often faces several challenges that negatively affect the experience of students, faculty, and canteen staff. These issues include long queues, missed meals, and food wastage, all of which lead to dissatisfaction. Traditional methods of order management and inventory control are prone to inefficiencies, human errors, and difficulty in predicting demand. This results in either food shortages or surplus, contributing to waste. The Smart Canteen Management System provides an effective solution by integrating real-time data processing and machine learning algorithms. The system predicts demand trends and optimizes inventory management, ensuring that food is available when needed. Users can place pre-orders and track their orders through a digital platform, reducing wait times and improving convenience. By accurately forecasting demand, the system minimizes food wastage, contributing to sustainability. This technological advancement enhances operational efficiency, streamlines order processing, and improves overall user satisfaction. The Smart Canteen Management System transforms traditional canteen operations, offering a more efficient, user-friendly experience for all stakeholders.

**Index Terms**—Canteen digitalization, Demand forecasting, Inventory Optimization, Machine Learning in Canteens, Pre-Ordering System.

## I. INTRODUCTION

College canteens play a crucial role in providing food services to students, faculty, and staff, ensuring their well-being and supporting their daily routines. However, traditional canteen management systems often encounter several challenges, including long queues, delayed order processing, manual inventory tracking, and excessive food wastage. These inefficiencies not only lead to customer dissatisfaction but also result in financial losses, resource mismanagement, and environmental impact due to wasted food.

To address these challenges, the Smart Canteen Management System integrates advanced technologies such as real-time data processing and machine learning algorithms to streamline canteen operations and enhance customer experience. The system provides a digital platform where users can view daily menus, place pre-orders, and receive instant notifications on order status, reducing wait times and ensuring meal availability. The machine learning model analyzes historical order data to predict food demand accurately, enabling canteen staff to optimize inventory management, prepare appropriate quantities of food, and minimize wastage. This predictive approach not only reduces operational costs but also promotes sustainability by minimizing food surplus.

The system also automates order tracking, inventory control, and payment processes, simplifying administrative tasks for canteen staff and reducing human errors. By automating routine operations, the staff can focus on improving food quality and customer service. The real-time data processing capability ensures that both users and staff have up-to-date information on order status and stock availability, promoting efficiency and transparency. In summary, the Smart Canteen Management System represents a significant step forward in modernizing food service operations through technology, ensuring faster service, reducing food wastage, and improving overall customer satisfaction. Its innovative use of machine learning and real-time data processing not only addresses the limitations of traditional canteen management but also sets a new standard for efficiency, sustainability, and user-centric service in food facilities.

## II. LITERATURE SURVEY

Canteen Management System (Ganadhis Navelkar et al.)[1]: This system digitizes the canteen operations by allowing users to place orders online, eliminating manual processes such as cash handling and order taking. It also incorporates a basic inventory management system. However, it does not include predictive features to anticipate user preferences or optimize meal choices. The system mainly focuses on improving order efficiency and reducing human errors but lacks personalization based on historical data or user preferences.

Canteen Management System Using Android (Amruta A. Patil et al.)[2]: This system enables users to order food via a mobile application, simplifying the ordering process and integrating online payment methods. While it addresses the inefficiencies of manual order processing and facilitates quicker transactions, the system does not predict meal preferences or suggest alternatives based on user behavior. Therefore, it offers convenience but does not focus on minimizing food wastage or ensuring that meals align with users' individual tastes.

Canteen Management System (Dr. C. Mahiba et al.)[3]: This system allows users to place orders and track them in real-time, providing updates on meal status. It also integrates fraud detection algorithms for secure payments. While the system improves efficiency and reduces waiting times, it does not leverage predictive technologies such as machine learning algorithms to anticipate users' meal choices. As a result, it lacks the ability to offer personalized meal recommendations, potentially leading to food wastage when users order meals they don't enjoy.

Cashless Canteen Management System (M. Ambika et al.)[4]: This system focuses on automating the canteen process with cashless transactions and advanced order tracking. While it addresses transaction time reduction, it did not integrate advanced functionalities like real-time food tracking, delivery options, and machine learning for inventory management, which enhances operational efficiency beyond just payment processing.

Canteen Management System (G.Sanjana Reddy et al.)[5]: This system specifically addresses queue congestion in college canteens by allowing students to

order meals before their break time through a web-based platform. Users must log in using their email addresses before placing an e-menu order. Once an order is placed, kitchen staff receive an alert to begin preparation, reducing waiting time. The system utilizes an SQL database to store user data, order history, and transaction logs. Additionally, it features a logging system to track user activity and ensure efficient monitoring of canteen operations.

Web based Canteen payment and ordering system(Fendy Fonggo et al)[6]: This system was developed to simplify transactions and reduce errors in payments and orders for tenants in a canteen. Using the Software Development Life Cycle (SDLC) Waterfall model, the system was designed to be user-friendly, efficient, and easy to implement. Observational studies and interviews with tenants and customers highlighted key challenges such as:Difficulties in handling both ordering and payment processes simultaneously, Errors in manual payment calculations, Long queues leading to operational inefficiencies and lost revenue, By implementing a web-based ordering and payment system, tenants were able to minimize these issues, ensuring smoother transactions and a better customer experience.

Intellicater - ML Powered Canteen Management System(Sangam Biradar et al)[7]: This system enhances the dining experience by providing personalized menu recommendations using machine learning. While it improves menu management and customer satisfaction through real-time feedback analysis, it lacks direct integration of demand forecasting and automated inventory management, which could further optimize food preparation and reduce wastage.

Canteen Management System(Mr. Raghav et al)[8]: Studies on canteen management systems highlight how digital ordering and inventory tracking improve efficiency by reducing wait times and automating processes. Research emphasizes the role of online platforms and AI-driven recommendations in enhancing menu management and personalization. The use of modern technologies like React and MongoDB ensures scalability and reliability, making canteen operations more seamless.

Cloud-Based Android App for College Canteen Management System (Mhalgi et al.)[9]: This system

proposes a cloud-based Android app designed to manage college canteens more efficiently. The app allows users to place orders, view the menu, and make payments directly from their mobile devices. By integrating a cloud platform, the system ensures real-time data synchronization and remote access, providing a smooth user experience. It also helps in inventory management and improves operational efficiency by enabling quick updates on food availability and order status. The use of cloud services ensures scalability and cost-effectiveness for college canteens. Enhancing User Experience through AI-Powered Chatbots (Chen & Zhang, 2021)[10]: This paper explores the use of AI-powered chatbots to improve user experience in customer service automation. The study demonstrates how chatbots can handle common customer inquiries, provide instant responses, and personalize interactions based on user behavior and preferences. By integrating natural language processing (NLP) and machine learning, these chatbots offer more accurate and efficient solutions compared to traditional methods. The authors emphasize the importance of continuous learning and adaptation for chatbots to improve over time, leading to enhanced customer satisfaction and operational efficiency.

### III. METHODOLOGY AND IMPLEMENTATION

The Smart Canteen Management System is designed to automate and optimize food service operations within a college canteen. The methodology involves a systematic approach to digitalizing canteen processes, ensuring efficient order management, real-time tracking, inventory automation, and enhanced user experience. The proposed system leverages modern web technologies, machine learning algorithms, and secure payment integration to enhance functionality

#### Research design

The research employs a quantitative and experimental approach to compare the efficiency of the smart canteen management system with traditional methods. Key phases include system development, data collection, machine learning model training, and performance evaluation. Success metrics include order processing time, food wastage reduction, and user satisfaction.

#### System Development

**Requirement Analysis:** Surveys and interviews with students, faculty, and canteen staff were conducted to identify challenges such as long queues, manual order processing, and inefficient inventory management.

This analysis informed the system's core functionalities: real-time menu display, pre-order placement, and automated inventory tracking.

**System Architecture:** Built using the MERN stack (MongoDB, Express.js, React, Node.js), the system includes three main modules:

**User Interface Module:** A responsive web interface enabling users to browse menus, place orders, and track order status.

**Order Management Module:** Processes real-time orders, updates stock levels, and notifies users of order status.

**Inventory Management Module:** Tracks inventory levels and leverages machine learning to predict demand.

#### Machine Learning Model

**Data Collection:** Historical order data is collected and preprocessed to ensure quality and consistency.

**Feature Engineering:** Relevant features such as time of day, seasonal demand, and individual user preferences are extracted.

**Model Selection:** Two machine learning models are integrated into the system:

**Demand Prediction using Prophet Model:**

The demand prediction is based on Prophet's additive model, represented as:

$$y(t)=g(t)+s(t)+h(t)+\epsilon t$$

$y(t)$  is the predicted order quantity at time

$g(t)$  represents the trend component, capturing long-term changes.

$s(t)$  is the seasonal component, modeling weekly and yearly seasonality.

$h(t)$  denotes holidays and special events.

$\epsilon t$  is the error term accounting for random fluctuations.

**Order Analysis using K-Means Clustering:**

To classify food items into high-demand and low-demand clusters, K-Means clustering minimizes the within-cluster sum of squares

$$J = \sum_{i=1}^n \sum_{j=1}^k \|x_i - c_j\|^2$$

$n$  is the number of data points (items).

k is the number of clusters (2 in this case: high demand and low demand).

$x_i$  is the data point (order count of each item).

$c_j$  is the centroid of cluster

$\|x_i - c_j\|^2$  represents the squared distance between the data point and its assigned cluster centroid.

### System Workflow

The Smart Canteen Management System streamlines order processing and inventory management through an organized workflow.

Users start by accessing the homepage, where they can explore the menu, place normal or pre-orders, track order statuses, and check payment details. For normal orders, users add items to the cart, complete online payments, and receive real-

time status updates from "Order Confirmed" to "Delivered." Pre-orders, ideal for bulk or next-day meals, follow a similar process, ensuring timely preparation. The admin dashboard provides real-time notifications for new orders and scheduled pre-orders, allowing efficient order categorization and preparation. Machine learning models, including Prophet for demand prediction and K-Means clustering for order analysis, guide admins in optimizing food preparation and reducing wastage. The system updates inventory levels based on orders, ensuring accurate stock management. Additionally, a chatbot is available to address user queries, providing instant assistance. This workflow ensures faster service, improved resource utilization, and enhanced user satisfaction.

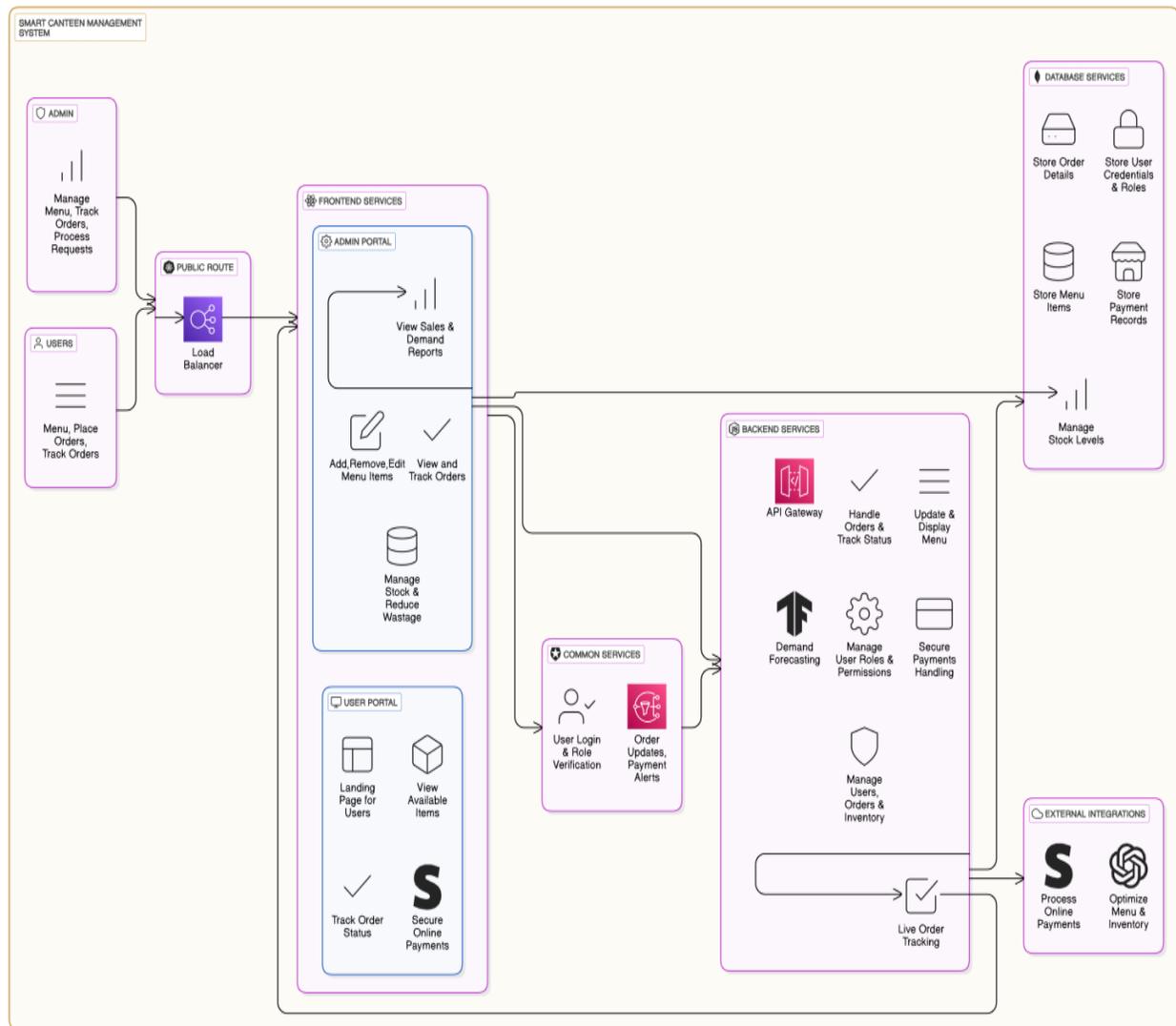


Fig 1: System architecture for user and admin workflow

Paper Name and Authors	Online Ordering	Real-time Tracking	Inventory Management	Payment System	Demand Prediction	Personalized Recommendations
Canteen Management System (Ganadhish Navelkar et al.)	Available	Unclear	Basic Inventory Management	Cashless Ordering	Not Available	Not Available
Canteen Management System Using Android (Amruta A. Patil et al.)	Available	Real-time Order Tracking	Limited Order Tracking	Online Payment Available	Not Available	Not Available
Real-Time Canteen Management System with Secure Payment Integration (Dr. C. Mahiba et al)	Available	Real-time Status Updates	Not Available	Secure Payment with Fraud Detection	Not Available	Not Available
Cashless Canteen Management System for Digital Transactions (M. Ambika et al.)	Available	Advanced Order Tracking	Automated Inventory Management	Cashless Payment System	Not Available	Not Available
Intelligent Canteen Optimization Using Machine Learning	Available	Real-time Menu & Status Updates	Automated with ML Predictions	Integrated Payment Gateway	Predicts Demand Using Machine Learning Algorithms	Planned: Personalized Meals

Table 1: Comparison Table of Existing Systems and Proposed System

#### IV IMPLEMENTATION

The implementation of the Smart Canteen Management System follows a structured approach to ensure seamless functionality, user accessibility, and efficient real-time operations. The system is built using the MERN stack (MongoDB, Express.js, React, Node.js) to provide a dynamic and responsive web application.

##### Admin-Side

**Dashboard:** Displays real-time notifications of incoming orders, scheduled pre-orders, and payment statuses. The dashboard is designed for quick navigation, allowing admins to monitor multiple processes simultaneously. Key metrics such as total daily orders, revenue, and pending payments are also displayed for better decision-making.

**Order Management:** Incoming orders are categorized based on order type and preparation status. Scheduled pre-orders are listed separately for timely preparation. The system prioritizes orders based on preparation time, ensuring that each meal is delivered fresh and on schedule. Admins can track order progress and manage unexpected delays by adjusting preparation workflows.

**Menu and Inventory Management:**The admin can update the daily menu, highlighting Today’s Specials and high-demand items. Machine learning algorithms analyze order patterns to predict demand, helping the admin restock ingredients before they run out. The system provides alerts when inventory levels are low, ensuring that popular items remain available throughout the day.

**Real-Time Status Updates:**The admin updates the order status as it progresses from preparation to delivery, ensuring users receive instant notifications. Each status update triggers an automated message that appears in the user’s Order Tracking section. This transparency helps reduce inquiries about order delays, improving customer satisfaction. The system also tracks preparation time for each item, helping the admin identify bottlenecks and optimize kitchen efficiency.

##### User-Side

**Homepage:** The homepage has options like Menu, Orders, Pre-Orders, Order Tracking, and Payment Status. Scrolling down shows different menu sections like Today’s Specials, Mostly Pre-Ordered, and Previous Orders and Feedback. It provides quick access.

**Normal Ordering:** Users select food items from the menu and click Add to Cart. After reviewing the cart, they click Place Order and complete the payment online. Once the payment is successful, the order appears in the Order Tracking section with real-time updates like Order Confirmed, Preparing, Ready for Pickup, and Delivered.

**Pre-Ordering:**For bulk orders or next-day meals, users go to the Pre-Orders section and add items to the cart. Payment is made during pre-order placement, and the order is scheduled for the next day. The tracking process is the same as for normal orders.

**Order History and Feedback:**Users can check their past orders and leave feedback in the Previous Orders and Feedback section.

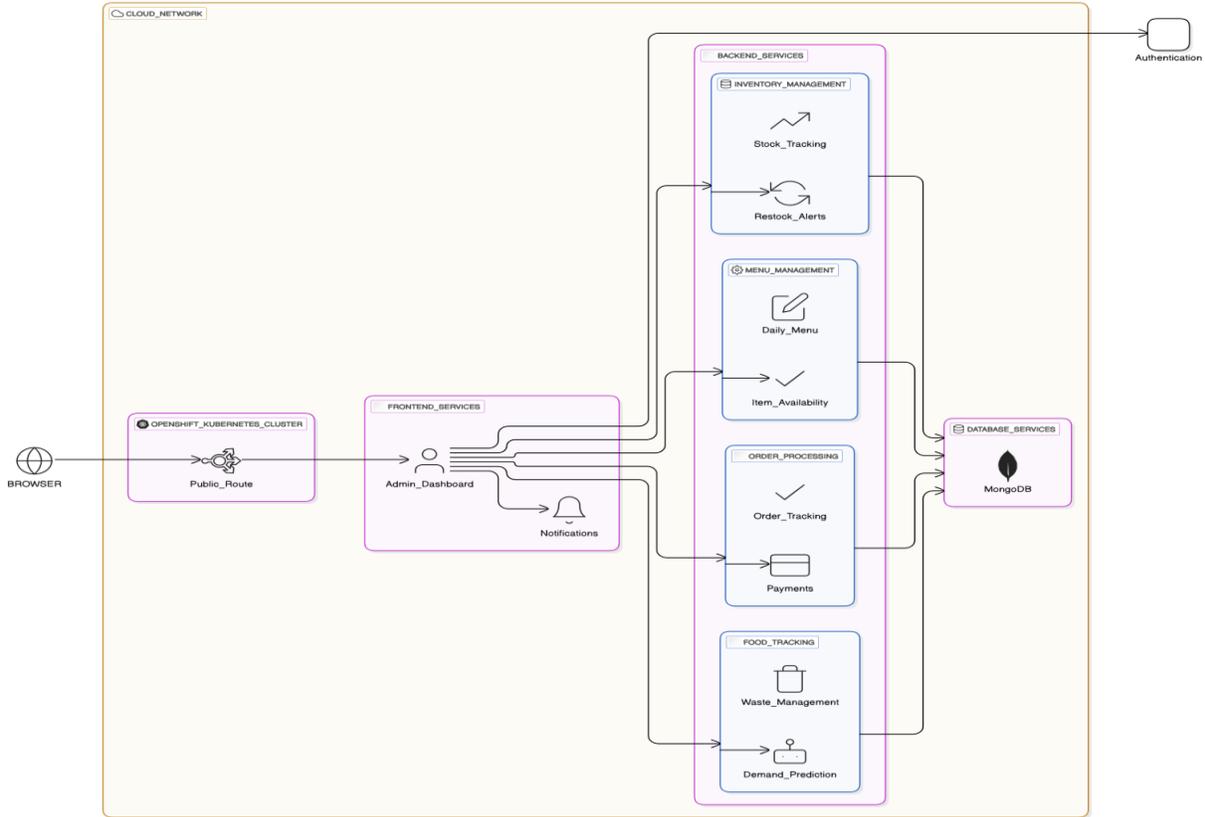


Fig 3: System Architecture of Admin Page

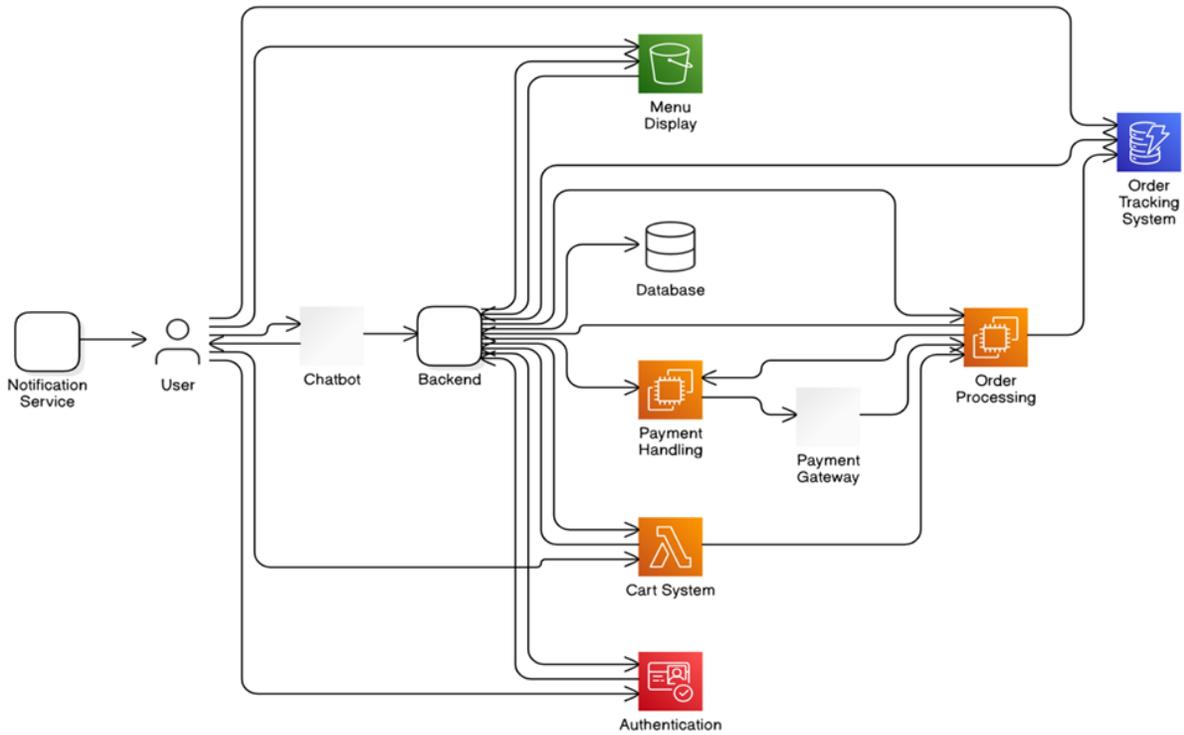


Fig 4: The System Architecture of User Page

Metric	Description	Value	Unit	Target	Status
Response Time	Time taken to load a page or process a request	1.8	Seconds	≤ 2 seconds	Pass
Prediction Accuracy	Accuracy of food demand prediction using ML	92%	Percentage	90%	Pass
Order Success Rate	Percentage of successfully placed orders	98%	Percentage	≥ 95%	Pass
Payment Processing Time	Average time taken to complete a payment	3.2	Seconds	≤ 5 Seconds	Pass
Up time System availability	over testing period	≥ 99%	Percentage	≥ 99%	Pass
Token Generation Time	Time taken to generate token after payment	1.1	Seconds	≤ 2 seconds	Pass
Load Handling Capacity	Maximum users handled simultaneously without crash	500+	Users	≥ 400 users	Pass

V RESULT ANALYSIS

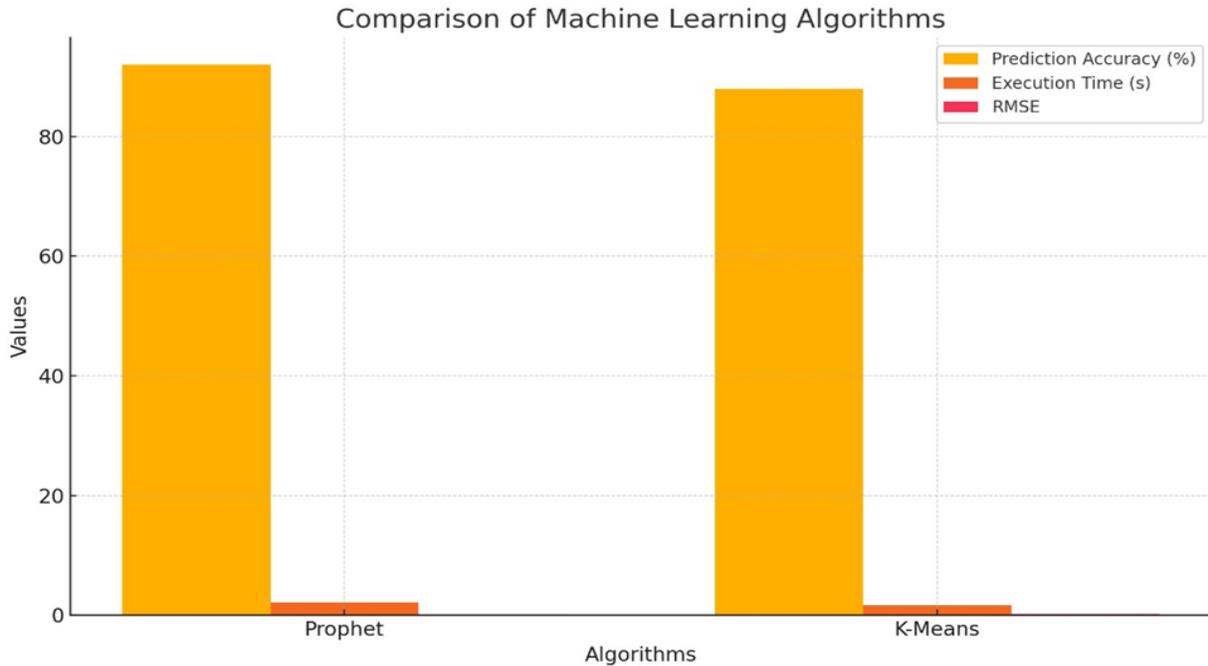


Fig5: Performance Analysis

6.CONCLUSION

The Smart Canteen Management System effectively addresses challenges faced by both users and canteen administrators by leveraging real-time data processing, machine learning techniques, and a user-friendly interface. The integration of the Prophet model for demand prediction and the K-Means clustering algorithm for order analysis enhances operational efficiency, minimizes food wastage, and

ensures optimal inventory management. Real-time order tracking and online payments improve the user experience, while pre-order options help manage bulk orders seamlessly. The system's chatbot offers quick responses to user queries, further enhancing customer satisfaction. Overall, the Smart Canteen Management System demonstrates a scalable and efficient approach to modernizing canteen operations, paving the way for future advancements in food service management. Future improvements include integrating advanced

deep learning algorithms to further optimize demand prediction and personalize menu recommendations based on individual preferences. Enhancing the chatbot with AI-powered natural language processing can provide more accurate and context-aware responses. Additionally, incorporating IoT-enabled sensors for real-time inventory monitoring and developing a mobile application version of the system can increase accessibility and operational efficiency, ensuring that the system continues to evolve to meet the growing needs of modern canteens.

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