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Technological Advancements in Vending Machines Transforming Consumer Behavior Market Trends and the Future of Automated Retail

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Abstract

In the rapidly evolving landscape of automated retail, vending machines have significantly expanded their presence, offering a wide array of products beyond traditional snacks and beverages. This systematic review explores the historical evolution, current trends, technological advancements, and consumer preferences related to vending machines. Historically, vending machines trace their origins to ancient Greece and have evolved from dispensing holy water to providing diverse offerings such as digital wallet top-ups and hot meals. The review highlights the pivotal role vending machines play in contemporary society, addressing their impact on dietary habits, especially in environments like schools, workplaces, and healthcare facilities. Technological advancements, including air fryer technology, fingerprint identification, and smart manufacturing, are examined for their potential to enhance vending machine functionality and security. Current trends reveal a growing demand for healthier food options and contactless services, driven in part by the COVID-19 pandemic. The review also underscores the need for sustainable practices, including the use of biodegradable packaging and energy-efficient machine designs. By synthesizing existing literature, this review aims to inform the development of a universal vending machine assessment tool and guide future innovations in vending machine technology to better serve consumer needs and promote healthier dietary choices.

Keywords: *Vending Machines, Technological Advancements, Consumer, Services, Sustainability*.

Introduction

In the era of advanced and rapidly evolving technology, the prevalence and visibility of vending machines have become increasingly notable in various environments such as food courts, convenience store sidewalks, and shopping malls. Vending machines are automated devices capable of dispensing food and beverages without human intervention. These machines come in diverse forms and offer a wide range of products, from simple snacks to digital wallet top-ups like Gopay. Historically, the concept of vending machines dates back to ancient Greece, where a mathematician from Alexandria invented a device to dispense holy water. The evolution of vending machines continued with Richard Carlie, a publisher and bookstore owner, who in 1822 created a machine for dispensing newspapers. The first vending machines for beverages emerged in 1890, with a notable machine in Paris, France, offering beer, wine, and liquor. The early 1920s

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saw the introduction of machines dispensing soda in plastic cups, and to this day, soft drinks remain among the most popular items sold through vending machines. Japan is renowned for its innovative use of vending machines, which offer a wide array of products including fruits, flowers, sushi, vegetables, hot meals, batteries, and sake.

According to Gruber (2016), a vending machine is an automated device that sells specific products, goods, and beverages in exchange for coins. With technological advancements, vending machines have evolved from coin-operated mechanisms to those accepting plastic money, thereby providing services at sales points without direct supervision. These machines are also described as electronic devices that dispense products or goods after a specific amount has been inserted. The increasing congestion in traditional markets frustrates customers and results in lost revenue for sellers (Gruber, 2016).

Monley (2011) highlights that purchasing vegetables often requires handling and inspecting them to assess quality, which can expose buyers to infectious diseases. Maintaining hygiene is crucial for preserving the quality of goods, necessitating higher wages and assurances for workers, as many customers use cash payments. Consequently, vending machines offer a practical solution to these challenges. The COVID-19 pandemic has further accelerated the global adoption of vending machines, with the market valued at $134.4 billion in 2020 and projected to reach $146.6 billion by 2027. Monley (2011) reports a compound annual growth rate (CAGR) of 1.3% from 2020 to 2027. Vending machines mitigate issues of negotiation and fraud, although there are risks of system hacking and vandalism. Heavy taxes on vending machine locations add to investment costs, while technical malfunctions and intentional damage can lead to significant financial losses for investors.

Vending machines are a crucial source of food, influencing dietary habits across different age groups. They can have both positive and negative impacts on the diets of children, teenagers, and adults (Rovner, Nansel, Wang & Iannotti, 2011). The widespread presence of vending machines in various settings affects food choices by providing convenient access to a range of unhealthy snacks and beverages (New & Kivingstone, 2003). Vending machines are now common in schools, universities, healthcare facilities, and workplaces. For individuals working extended hours, vending machines may represent the only available food source, underscoring the need for healthy options (Escoto et al., 2010). Similarly, in university settings and other institutions with limited dining options, vending machines can become the sole source of food and beverages (Byrd-Bredbenner et al., 2012; Lawrence et al., 2009).

As vending machines become increasingly prevalent, their impact on individual energy intake grows, highlighting the need to assess and monitor the nutritional value of the products they offer. Nutritional behavior is significantly influenced by the availability and accessibility of food. Thus, monitoring and evaluation are essential for understanding food environments and dietary patterns. This systematic review aims to summarize, compare, and evaluate existing literature on vending machine assessment methodologies (Jamaludin et al., 2018). The insights gained will inform the development of a universal vending machine assessment tool. Given the widespread presence of vending machines in schools and their role in shaping dietary habits during critical developmental periods, this research also addresses the need for interventions to promote healthy food choices and improve nutritional quality (Alice Rosi, 2017; Nilani Ratnasri, 2021).

Literature Review

The purpose of this literature review is to examine and analyze existing research on vending machines. This review focuses on improvements in service and the diversity of products offered by vending machines. It encompasses trends in food selection provided by vending machines, their impact on individuals, and technological advancements in vending machine innovations that can meet societal needs and demands. By providing a comprehensive overview of current research, this review aims to identify key themes, methodological approaches, and gaps in the existing literature. This understanding is crucial for guiding our research, which aims to enhance services and diversify the product offerings of vending machines. Such improvements are expected to benefit various societal groups, especially students and workers. Additionally, as Malaysians, our primary mission is to introduce new products, such as traditional Malaysian foods like nasi lemak and traditional food, as well as various other packaged local food products. One key feature we aim to highlight is that every food item purchased can be enjoyed while still hot. Moreover, we emphasize the selection of healthy and nutritious food for consumers.

Themes and Categories of Study

Consumer Preferences

This theme focuses on understanding user behavior and the actual needs and requirements of users regarding vending machines. Most studies indicate that user expectations from vending machines include ease of use and accessibility. Sibanda et al. (2020) discussed the real-life scenario where individuals often spend twenty to thirty minutes obtaining ordered food from stores. They suggest that vending machines can save users 75% to 83% of this time by providing orders within five minutes or less. The importance of vending machines operating 24/7 is emphasized due to their high reliance, especially among students and workers. Furthermore, high-tech vending machines have significant potential to serve as business platforms. Hasan et al. (2021) examined vending machines from a nutritional perspective, identifying them as a potential factor contributing to obesity, particularly among university students. Their study involving 1,250 students and university staff highlighted the importance of offering healthy food options in vending machines. Similarly, Pechey et al. (2019) evaluated how the availability of healthier food options in vending machines within hospitals can influence users' behavior towards healthier food choices. Belyaeva et al. (2023) explored vending machine technology in Russia, showcasing advancements and current trends in the industry, including machines that provide a variety of foods such as potato balls, french fries, and complete meals.

Technological Advancements

To develop a high-tech vending machine, we reviewed various technological applications used in previous studies. Belyaeva et al. (2023) outlined technological advancements, including the use of air fryer technology, which allows for the preparation of healthier foods through vending machines. Sibanda et al. (2020) proposed the integration of advanced technologies, such as fingerprint identification for enhanced security, information systems including HTML, JavaScript, and CSS, and innovative mechanisms like robotic arms. Their study also incorporated technological and innovative applications to prevent vandalism and serve as an advertising platform displaying digital promotional content. Al-Shareeda et al. (2023) applied smart manufacturing technology through cloud computing and the Internet of Things (IoT) to manage vending machine orders, payments, and inventory.

Current Trends

This study also investigates current trends in vending machine use to understand the relationship between environmental factors and consumer choices when using vending machines. Pechey et al. (2019) emphasized the growing public awareness of health factors, noting a shift towards selecting healthier, nutrient-rich, and protein-rich foods over snacks. The study also touched on how the location of vending machines affects consumer behavior in surrounding areas. Vending machines in health-related premises were found to influence users towards healthier food choices. Belyaeva et al. (2023) also addressed the trend towards healthier food choices with the use of air fryer technology and highlighted the increased demand for contactless services due to the COVID-19 pandemic. The pandemic has driven a global shift towards digital transactions, including online payments for food purchases. Sibanda et al. (2020) and Hasan et al. (2021) also discussed the global trend towards healthier food choices, driven by increased health awareness. However, an additional consideration highlighted by some authors is environmental sustainability. They recommend using sustainable and biodegradable packaging for vending machine products and suggest designing energy-efficient machines with features such as LED lighting to promote energy conservation.

2.2 Results and Findings

The analysis of various journals, including Hasan et al. (2021), which explores why people choose to use vending machines, provides insights into the frequency of vending machine usage among society.

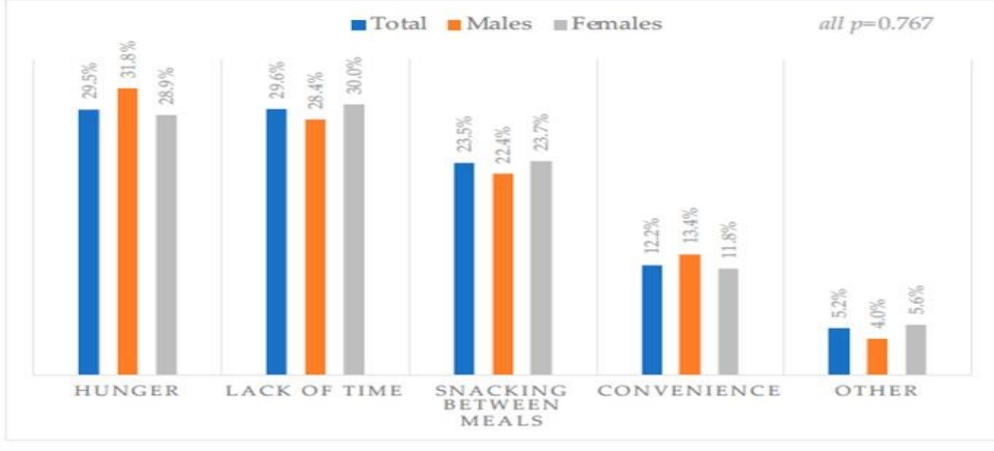

Figure 1: Purpose of Vending Machine Use Among the Public

According to Pechey et al. (2019), reducing the availability of unhealthy drinks in vending machines led to a decrease in the number of users purchasing these unhealthy beverages. A similar effect was observed with unhealthy snacks provided in vending machines.

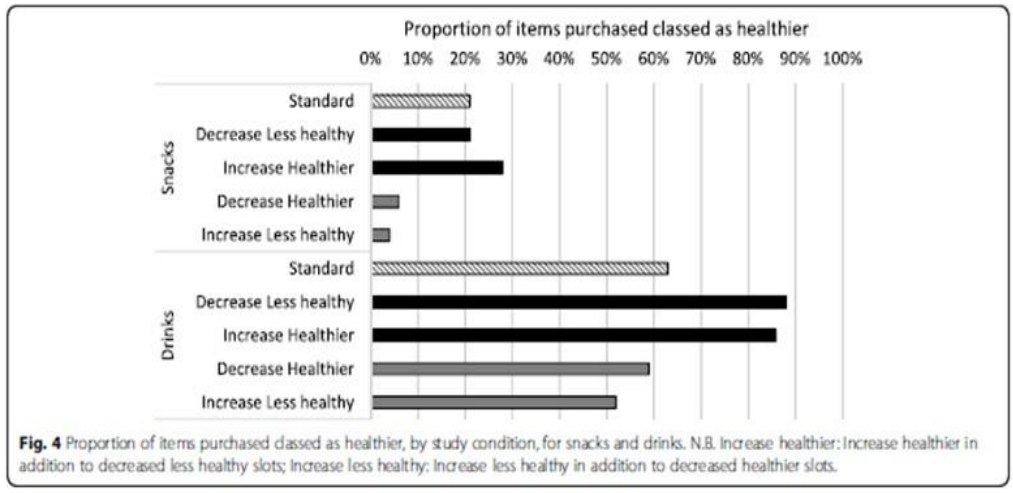

Fig. 4 Proportion of items purchased classed as healthier, by study condition, for snacks and drinks. N.B. Increase healthier: Increase healthier in addition to decreased less healthy slots; Increase less healthy: Increase less healthy in addition to decreased healthier slots.

Figure 2: Statistics on the Purchase of Nutritious Foods

Belyaeva et al. (2023) conducted a survey to determine the types of food that should be available in vending machines. Their findings revealed a high demand for products such as waffles, croissants, sandwiches, tea, coffee, and snacks. Consequently, it is rational to create food products that incorporate healthy characteristics, as suggested by Belyaeva et al. (2023).

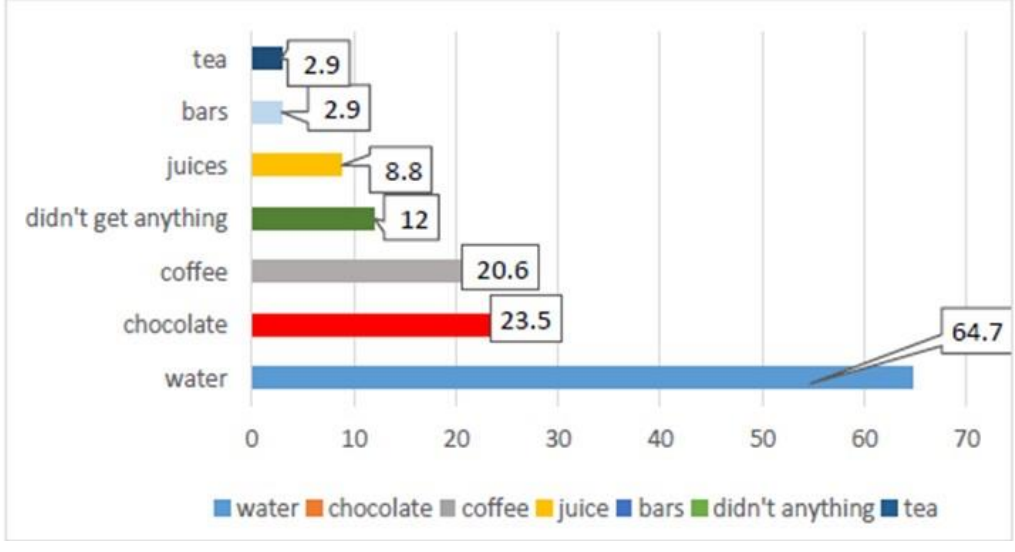

Figure 3: Types of Items Needed in Vending Machines

Methodology	Key Finding	Source
Analysis of Sales Data and Survey of Hospital Staff and Visitors Using Vending Machines	The increased availability of healthier food options has led to a higher selection of these options over less healthy alternatives by customers.	Al-Shareeda et al., (2022)
Conducting surveys, focus groups, and analyzing transaction data from vending machines placed at various locations.	Users are increasingly opting for healthier food choices when using vending machines. Trends also indicate a rise in the availability of healthy food options through these machines.	Hasan et al., (2021)
To investigate how applied technology in vending machines can improve the quality of food services provided. This involves case studies and interviews.	The implementation of advanced technology in vending machines, such as touch screens and mobile payment options, can enhance service efficiency and customer satisfaction.	Belyaeva et al., (2023)
Applying engineering design, implementing the Internet of Things (IoT), and collecting user feedback.	This approach can enhance vending machine efficiency, improve inventory management, and enrich user experience.	Al-Shareeda et al., (2022)
Utilizing engineering design, Pugh Matrix evaluation, and technologies such as HTML/JavaScript for advertising platforms.	This enables the development of vending machines equipped with robotic arms, fingerprint recognition, and security alarm systems, functioning also as advertising platforms. These innovations can improve efficiency and reduce customer wait times.	Sibanda et al., (2020)

Table 1: Summary of Selected Studies on Vending Machines

Current Issues in Self-Service Vending Machines

This study examines and analyzes contemporary issues associated with self-service vending machines. As previously discussed, vending machines offer numerous advantages to both users and premises owners. For users, these machines provide significant convenience and flexibility (Griffiths et al., 2020). Accessible 24/7, vending machines enable users to purchase items at any time, including outside regular store hours. This is particularly valuable in locations such as hospitals, airports, and gas stations, which operate around the clock. Furthermore, vending machines typically offer a rapid and straightforward purchasing process, utilizing touchscreens or simple buttons, which is advantageous in busy environments where speed is essential (Jamaludin et al., 2022).

Premises owners also benefit from vending machines. These devices allow them to offer additional services to customers or employees without hiring extra staff to manage sales (Griffiths et al., 2020). This reduces labor costs and allows business owners to focus on their core operations. Additionally, vending machines have the potential to generate supplementary income. By strategically placing and maintaining these machines, premises owners can achieve a steady revenue stream with minimal operational costs.

However, self-service vending machines face several significant challenges that need addressing to meet market and societal demands (Ratnasri & Sharmilan, 2021). This paper analyzes four primary issues: the lack of healthy food and beverage options, the absence of hot food choices, limited payment methods, and inventory management challenges.

Lack of Healthy Food and Beverage Options

A prominent issue with vending machines in Malaysia is the limited availability of healthy food and beverage options (Syed Jaymal Zahiid, 2023). While vending machines are known for their convenience, they are often associated with unhealthy food choices. This trend is influenced by several factors. Firstly, shelf life and maintenance are critical considerations (Griffiths et al., 2020). Processed snacks generally have a longer shelf life and require less maintenance, which is important as vending machines may not be restocked daily. In contrast, fresh foods such as fruits and vegetables have a shorter shelf life and require strict temperature control, making them less suitable for vending machines. Additionally, taste and appeal play a significant role in stock selection. Processed snacks, often high in salt, sugar, and fat, are more palatable and visually appealing, leading to quicker purchasing decisions. Healthy options like salads or yogurt may be perceived as less attractive and require more deliberation (Amborashang & Seman, 2022).

The predominance of unhealthy snacks in vending machines can have serious health implications. Reliance on vending machines for daily snacks may lead to excessive intake of calories, sugar, and fat (Rozman et al., 2020), contributing to health issues such as obesity, diabetes, and cardiovascular diseases. Moreover, the lack of healthy options can be problematic for individuals trying to maintain a nutritious diet, particularly for those working in office environments or studying in educational institutions where vending machines offer a convenient snack choice. For children, the availability of unhealthy snacks can undermine healthy eating habits, as they may opt for sugary or salty snacks instead of more nutritious options.

Addressing the trend of unhealthy snack offerings in vending machines is essential. Governments and vending machine operators should promote a wider range of healthier options. This can be achieved by providing incentives for companies to offer more nutritious products or by establishing guidelines for the nutritional content of items sold. By prioritizing consumer health, vending machines can continue to provide benefits to all stakeholders.

Lack of Hot Food Options

Another significant issue with vending machines in Malaysia is the lack of hot food options. Several factors hinder vending machines from offering hot meals. The primary obstacle is technological limitations (Maras, 2024). Vending machines are designed to store and dispense food and beverages at room temperature or chilled. Integrating a safe and efficient heating system requires a more complex and costly machine design. Furthermore, maintaining hot food temperatures over extended periods necessitates high energy consumption, which increases operational costs. Safety concerns also arise; the risk of fire and burns from handling hot food requires stringent temperature control and secure packaging, further complicating machine

operation (Mustapha et al., 2023).

The absence of hot food options can negatively affect dietary habits. Users who rely on vending machines for snacks or meals may resort to processed, less nutritious foods, leading to deficiencies in essential nutrients and increased risk of health issues such as obesity and malnutrition (Rozman et al., 2020). Busy workers or students lacking access to convenient hot food options may skip meals or purchase more expensive, potentially less healthy food from external sources.

Despite technological and safety constraints, efforts to provide hot food options in vending machines should continue. Innovations in technology and safe packaging solutions can help achieve this goal (Maras, 2024). By offering a diverse range of food choices, users can make healthier decisions that meet their nutritional needs.

Limited Payment Methods

In Malaysia, vending machines rarely accept credit cards, debit cards, or digital wallets such as QR Pay, creating inconvenience for users who must carry sufficient cash. In contrast, vending machines in many other countries, such as Japan, have adopted digital payment methods including e-wallets, QR codes, and credit cards (Katsuhiko Fujino, 2023). Malaysian vending machines are lagging and need modernization to remain competitive.

Several factors impede the adoption of digital payment methods for vending machines in Malaysia. The cost of installing and maintaining electronic payment technology is a major barrier. Integrating card readers or QR code scanners requires additional investment compared to existing cash-based systems (Wahidul Alam et al., 2021). Moreover, transaction fees imposed by digital payment platforms can reduce profitability for vending operators, particularly for machines selling low-priced items. Infrastructure compatibility is also a consideration, as some areas may have limited internet access, hindering the use of electronic payment systems that require stable connectivity.

Reliance on cash for vending machine transactions can lead to user inconvenience. Those without sufficient cash may miss out on purchasing needed items (Wahidul Alam et al., 2021), which is particularly problematic in locations like hospitals or airports where access to ATMs may be limited. Additionally, cash transactions limit the use of rewards and promotions offered by credit cards or digital wallets, leading users to seek alternatives with electronic payment options.

Inventory Management Issues

Despite the promised 24-hour convenience of vending machines, frequent stockouts are a common issue in Malaysia. Machines running out of stock not only frustrate users but also impact business operations and reputation. Several factors contribute to the frequent stockouts in vending machines. Inaccurate demand forecasting is a primary cause. Insufficient stock to meet user demand results in quick depletion. This may be due to inadequate sales data or sudden changes in purchasing patterns. Inefficient restocking processes also contribute. Long intervals between restocking can lead to machines running out of items, especially in high-demand locations. Additionally, complex and time-consuming restocking procedures can affect operational efficiency.

To address the issue of frequent stockouts, several measures can be implemented. Operators should analyze sales data to improve demand forecasting accuracy. Efficient and frequent

restocking systems are essential to ensure machines remain adequately stocked (Ratnasri & Sharmilan, 2021). For example, Internet of Things (IoT) technology can be employed to monitor stock levels in real-time. Sensors installed in machines can detect remaining inventory. When stock levels reach a predefined minimum, sensors send data to an inventory management system, which analyzes the data and places automatic orders (Wahidul et al., 2021). This system ensures machines are consistently stocked and streamlines the ordering process, saving time and labor. Enhanced inventory management will improve user satisfaction and overall vending machine performance.

Recommendations

To enhance the effectiveness, user satisfaction, and overall impact of vending machines, the following recommendations are proposed:

Strategic Placement: The strategic placement of vending machines is essential to maximize their visibility and accessibility. Optimal locations include high-traffic areas such as office buildings, educational institutions, train stations, shopping malls, and recreational areas. These sites are frequented by a diverse group of people, ensuring that the machines are used frequently. Additionally, machines should be positioned in easily visible and accessible spots to attract users and encourage frequent use. Placement near entrances, break rooms, or common areas can significantly increase the likelihood of usage.

Diverse Product Selection: Offering a diverse range of products caters to different consumer preferences and needs. Vending machines should stock a variety of items, including both hot and cold beverages, snacks, light meals, and healthier options such as fresh fruit, yogurt, and salads. This variety ensures that users can find something that suits their preferences and dietary requirements. Additionally, including everyday essentials, such as hygiene products or office supplies, can address practical needs and further enhance the machine's utility. Tailoring product offerings to the specific demographic of the location—such as including healthier options in locations frequented by health-conscious individuals—can improve satisfaction and increase usage.

Product Quality and Safety: Maintaining high standards of product quality and safety is crucial. All items dispensed by vending machines should be fresh and in good condition to ensure user satisfaction and safety. Implementing a robust stock rotation system helps prevent the sale of expired or spoiled items. For products requiring refrigeration, the vending machines should be equipped with reliable temperature control systems to maintain the proper storage conditions. Regular checks and maintenance should be conducted to ensure that the machines are functioning correctly and that all products are stored safely.

Convenient Payment Systems: Facilitating a smooth and convenient payment process is key to enhancing user experience. Vending machines should offer multiple payment options, including prepaid cards, contactless payment methods, and mobile payment apps such as Touch 'n Go e-wallet and Apple Pay. Providing diverse payment methods caters to the preferences of different users and minimizes transaction friction. Ensuring that the payment systems are user-friendly and function seamlessly can prevent frustrations and encourage more frequent use of the machines.

Promotions and Special Offers: Attracting users through promotions and special offers can drive increased usage and engagement. Implementing strategies such as offering discounts on certain products, buy-one-get-one-free deals, or loyalty rewards for frequent users can

incentivize purchases. Advertising these promotions effectively within or around the vending machine—through posters, digital screens, or signage—can capture users' attention and encourage them to take advantage of these offers. Regularly updating promotions and offers can also keep the user experience fresh and engaging.

Maintenance and Upkeep: Regular maintenance and upkeep are essential for ensuring the reliability and longevity of vending machines. Routine inspections should be conducted to ensure that all components, such as coin mechanisms, dispensing systems, and temperature controls, are functioning properly. Promptly addressing any technical issues or malfunctions helps maintain a positive user experience and prevents downtime. Scheduled maintenance can prevent small issues from becoming major problems and ensure that the machines operate smoothly.

User Feedback: Collecting and utilizing user feedback is crucial for ongoing improvement. Feedback can be gathered through various methods, such as user surveys, suggestion boxes located near the machines, or social media platforms. Analyzing this feedback provides valuable insights into user preferences, issues, and suggestions for improvement. Incorporating user feedback into product offerings, machine features, and overall service can enhance user satisfaction and ensure that the vending machines continue to meet the needs of their users effectively.

Conclusion

Enhancing the quality and service of vending machines is pivotal in addressing the evolving needs of users who demand convenient and efficient access to food and beverages. To achieve this, operators should focus on strategic placement in high-traffic areas like office buildings, educational institutions, and transportation hubs, which maximizes visibility and accessibility. Offering a diverse range of products, including healthy options, caters to varied consumer preferences and dietary requirements, promoting better health and user satisfaction. Maintaining rigorous quality and safety standards through regular stock checks and temperature controls ensures product freshness and user trust. Modernizing payment methods to include digital and contactless options simplifies transactions and aligns with the trend towards cashless payments. Implementing effective promotions, such as discounts and loyalty programs, can attract and retain users while enhancing visibility through in-machine displays or external advertising. Regular maintenance and prompt repairs are essential to minimize downtime and user frustration, ensuring reliable operation. Leveraging technology for real-time stock monitoring and flexible payment options further optimizes efficiency and user experience. By integrating these strategies, vending machine operators can significantly improve user satisfaction, positioning vending machines as a reliable and practical solution for the nutritional and convenience needs of students, employees, and other consumers.

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