Research on Fresh Produce Inventory Management at D Supermarket

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Abstract: Fresh produce is an essential daily consumer item characterized by high demand, perishability, and a short shelf life. As living standards improve, consumer demand for healthy, safe, and fresh produce continues to grow. Supermarkets, as a key sales channel for fresh produce, see their operational efficiency directly impacted by inventory management levels. Therefore, adopting scientific and effective inventory control strategies is crucial for enhancing supermarket inventory management. This paper examines the current inventory status at Supermarket D, analyzes the primary issues in its fresh produce inventory management, and proposes targeted solutions based on these findings. The aim is to provide valuable insights for related research.

Keywords: Fresh Produce; Inventory Management

1.Introduction

Fresh produce is characterized by its perishability, strong seasonality, short shelf life, and high unpredictability. In today's society, people increasingly prioritize quality of life and place greater emphasis on the quality and safety of fresh food. Data indicates that consumers exhibit high purchase frequency for fresh food, further confirming their stringent demands for product quality. As shown in Figure 1-1, Chinese consumers purchase fresh products approximately 3 times per week on average—higher than the global average of 2.5 times. This frequency is particularly pronounced for fruits and vegetables, with weekly purchases reaching 4.8 times. Sales of fruits and vegetables account for the largest share of total sales at around 55%, followed by meat/poultry/protein products (17%) and seafood (16%)[1]. Both purchase frequency and sales volume indicate shifting consumer habits, with heightened expectations for fresh produce quality. As purchasing power increases, fresh supermarkets have become the primary retail channel for fresh goods, especially in developed cities like Beijing, Shanghai, Guangzhou, and Shenzhen. Consumers now prioritize not only affordability but also product quality and shopping experience. To meet this growing demand, governments at all levels have promoted the "farm-to-supermarket" strategy, leading to an increasing market share for fresh supermarkets. International experience shows that in Europe, the United States, and developed Asian countries, supermarkets account for the majority of fresh produce sales, reaching 93% and 70% respectively[1]. However, fresh products are prone to spoilage and have short shelf lives, making inventory management challenges persistent. Issues such as arbitrary purchasing and inaccurate demand forecasting lead to expired goods and unsold inventory. To enhance sales efficiency and reduce losses, fresh produce supermarkets must strengthen inventory management

and optimize strategies to meet consumers' high expectations for freshness and quality.

2.Literature Review

2.1 Inventory Classification Management

Inventory classification management involves categorizing different products based on distinct characteristics to enable targeted management. The resulting classifications allow for tailored management approaches suited to varying operational scenarios, thereby improving the rationality of supermarket inventory structures and enhancing operational efficiency and management standards. The ABC classification method has been widely adopted across industries for inventory categorization. However, since this approach typically relies on a single factor as the classification criterion, the resulting categories, while meaningful for inventory management, may not necessarily be the most efficient. Consequently, multi-criteria classification methods have garnered significant attention in both academic circles and practical applications in recent years.

Balaji proposed a multi-criteria ABC classification method for the automotive rubber parts manufacturing industry. Based on multiple criteria including demand, unit price, annual consumption value, unit weight, and component shape, they employed the Analytic Hierarchy Process (AHP) to enhance the traditional ABC method for classifying rubber components. This approach addressed issues of improper material allocation and inefficient inventory handling processes[2]. Yang proposed a novel integrated MILP model to simultaneously optimize multiple inventory classification and control decisions, enabling profit maximization under non-stationary demand.[3] Ishizaka introduced the DEASort method based on traditional ABC classification, integrating the weighting capabilities of AHP to address multi-criteria classification problems. Case studies demonstrated that the improved classification method achieved significant cost savings compared to the ABC classification approach.[4] Maganha proposed a multi-criteria classification method based on the combination of the Fuzzy Analytic Hierarchy Process (FAHP) and the Analytic Binary Comparison (ABC) technique. By applying selected criteria, they categorized 345 parts into three classes, enabling the implementation of differentiated inventory management strategies to enhance the efficiency and scientific rigor of inventory management[5].

The ABC classification method is currently the most widely applied categorization approach in China, frequently employed across various sectors. Ma Yuwen utilized the ABC classification method to categorize and manage pharmaceuticals in hospital drug warehouses, establishing specific procurement limits and cycles for each category. This approach enhances the scientific rigor of inventory management, improves drug turnover rates, and reduces capital tied up in inventory[6] Chen applied the ABC classification method to manage high-value consumables in operating rooms. They proposed distinct inventory management strategies for three categories of supplies and implemented these strategies in practice. This resulted in a significant increase in inventory turnover rates for consumables and an improvement in shortage incidents[7]. As enterprises place increasingly stringent demands on inventory management, the traditional and readily applicable ABC classification method no longer meets their management needs. Scholars and practitioners have therefore refined conventional classification approaches based on the unique characteristics of individual businesses. Existing domestic literature contains limited research on inventory classification management for fresh produce enterprises. Some studies employ the Analytic Hierarchy Process (AHP) to enhance traditional ABC classification. For instance, Qi Yongfang (2013) introduced AHP to refine ABC classification by incorporating multiple criteria beyond capital occupation—including warehouse facilities, stockout impacts, seasonality, and procurement difficulty—thereby optimizing inventory for SC Company and achieving more scientific and reliable inventory management[8]. Xu similarly introduced the Analytic Hierarchy Process (AHP) to enhance the ABC classification method. First, the ABC classification method was used to categorize fresh products into three major groups. Subsequently, the AHP method was applied to further analyze the key Category A products requiring intensive management, thereby generating more targeted management recommendations[9].

2.2 Inventory Control Optimization

Numerous factors influence inventory control, and perishable goods require consideration of even more aspects. Scholars have conducted research on various influencing factors accordingly.

In the early stages of research, many scholars assumed that demand for perishable products was deterministic, positing demand as either constant or as a function of influencing factors such as time, price, and freshness. For instance, Yu and others assumed demand was related to price and inventory levels, studying inventory models under carbon cap constraints[10]. Banerjee hypothesize that demand depends on freshness and price, and investigate optimal ordering decisions under discount promotions[11]. However, product demand often exhibits significant uncertainty. When addressing uncertain demand, scholars typically consider scenarios where demand follows a specific distribution or where the demand distribution is unknown. For instance, Abdel-Aal and others assume market demand follows a normal distribution. Based on the CVaR criterion, they established a multi-product newsboy model under three risk aversion levels and employed algorithms for solution. Ultimately, this yields two decision outcomes: the market to serve and the product order quantity[12].

Han Shuguang assumed that demand is related to transportation time and freshness, analyzing the order cycle and order quantity that maximize profit[13]. In studies considering quantity discounts, Zhang introduced quantity discount contracts to coordinate supply chains for time-delayed perishable goods, enabling the entire supply chain system to achieve an optimal state under centralized decision-making[14]. In studies considering spoilage rates, Wei investigated inventory problems under a two-parameter Weibull distribution for spoilage rates. Aiming to minimize the retailer's average total cost, they established a retailer inventory model and employed genetic algorithms to plan and solve inventory and screening strategies[15]. In studies addressing simultaneous ordering of multiple products, Chen developed a multi-product Marquis demand boy model with capacity constraints under stochastic demand, integrating the theoretical foundation of the multi-product Marquis demand model. This approach yielded optimal ordering strategies for multiple products[16-17].

3.Current Status of Fresh Produce Inventory Management at D Supermarket

3.1 Current Inventory Status

D Supermarket offers an extensive variety of fresh produce, displayed in distinct sections by category. Shelves feature a wide selection of items with clear, easy-to-read pricing, enabling customers to quickly and conveniently choose their desired products. The supermarket's fresh food offerings are primarily divided into four major categories: vegetables, fruits, meats, and seafood. The specific classification structure is shown in Table 2-1 below.

Tbale 2-1 D Supermarket Fresh Produce Categories

Name	Classification	Subcategory
Fresh Produce	Vegetables	Tomatoes, broccoli, cauliflower, bell peppers, lettuce, round eggplant, dried ginger, potatoes, parsley, baby bok choy, romaine lettuce, long beans, spinach, cucumbers, green peppers, yellow cabbage, zucchini
	Fruit	Cherries, Red Fuji apples, plums, passion fruit, blueberries, cantaloupe, dragon fruit, avocados, mangoes, green dates, lemons, nectarines, watermelon, peaches
	Meat and Poultry	Chilled Free-Range Chicken, Fresh Beef Short Ribs, Fresh Lamb, Fresh Beef, Pork Trotters, Beef Steak, Beef Shank, Pork Loin, Frozen Chicken Wings, Frozen Shrimp, Chilled Chicken Drumsticks
	Seafood	Burbot, Fresh Seafood Shrimp, Hairy Crab, Fresh Sea Bass

D Supermarket primarily operates fresh goods including meat, seafood, fruits, and vegetables. By the end of 2024, the total inventory of fresh food slightly increased, rising 3% compared to the same period last year. With processing centers directly supplying standardized products, inventory of meat and poultry has significantly decreased, accepting only select varieties for processing and repackaging sales. Among the four categories, fruit holds the largest share exceeding 30%, showing an upward trend over the past year. Seafood and vegetable reserves have also steadily increased. However, despite rising inventory levels, sales have not grown significantly, instead increasing operational pressure on the store. The specific

inventory composition is detailed in Table 2-2.

Table 2-2 2024 Inventory Composition Statement

Inventory Items	2022/4/30			2022/8/31			2022/12/31		
	Quantity (kg)	Amount (W)	Percentage	Quantity (kg)	Amount (W)	Percentage	Quantity (kg)	Amount (W)	Percentage
Fruit	12065	360	30.48%	11461	346	30.01%	13201	375	31.38%
Vegetables	6905	231	19.56%	7139	242	20.99%	7476	258	21.59%
Meat poultry	6430	253	21.42%	5871	225	19.51%	4587	195	16.32%
Seafood	5470	337	28.54%	6860	340	29.49%	7060	367	30.71%
Total	30870	1181	100%	31385	1153	100%	32324	1195	100%

3.2 Current Status of Losses

Losses at Supermarket D typically refer to packaging damage during distribution and handling, spoilage of fresh produce during transportation, and products nearing their expiration dates within the supermarket.

Field research and data collection reveal that packaging damage during transportation accounts for only a small fraction of losses. The primary causes stem from products expiring, deteriorating, or rotting. When supermarket fresh produce managers relay purchase order information to procurement departments, they often rely on personal experience and subjective judgment, potentially leading to over-ordering. This results in declining product quality, wasted shelf space, and increased losses. Furthermore, the inability to accurately predict consumer demand leads to large quantities of fresh produce being stockpiled. Given their typically short shelf lives, these products often cannot be sold before expiring, resulting in significant losses. Ultimately, D Supermarket's fresh produce losses stem from improper inventory management, causing product dehydration, quality degradation, and quantity reduction. This forces the supermarket to sell items at discounted prices or even remove them from shelves for disposal. Unsold fresh produce not stored in warehouses holds no residual value and can be termed "waste volume." This waste volume equals the ordering quantity minus the inventory quantity, where the ordering quantity is the sum of market demand and residual inventory. Thus, the waste rate for a given fresh product = waste volume / ordering quantity.

Analysis of the organized data from the fresh produce inventory management system reveals that the inventory loss rate for certain fresh products at Supermarket D exceeds the stipulated 5% threshold. The industry standard average loss rate for fruits and vegetables ranges from 2% to 3%[30], and Supermarket D's rate surpasses this, indicating room for improvement in its fresh produce management. While loss in fresh products cannot be entirely avoided, losses can be minimized through optimized management practices.

3.3 Current Status of Ordering Strategies

D Supermarket faces numerous management issues in its fresh produce sales. First, the extensive variety of fresh products lacks clear and scientific categorization, leading to irregular and highly subjective ordering practices. Second, for fast-moving consumer goods like vegetables and fruits, ordering considers only historical sales volumes without accounting for fluctuations and randomness in customer demand, resulting in inflexible ordering plans. Additionally, D Supermarket faces severe inventory backlog issues, significantly diminishing the freshness of its products. This negatively impacts both brand image and customer shopping experience. Based on field research and data provided by the supermarket regarding procurement, sales, and inventory, demand information for 50 fresh produce items was compiled.

4.Inventory Management Issues

4.1 Excessive inventory costs

D Supermarket is currently in a phase of rapid expansion. Although it employs traditional inventory management practices, it has adopted a strategy of increasing safety stock levels to prevent stockouts. However, this approach has resulted in excessive inventory levels at both store warehouses and distribution centers, leading to unsold goods and increased inventory costs. Given the short shelf life of D Supermarket's fresh produce, which is prone to spoilage, timely sales are essential. Excessive inventory accumulation causes fresh products to lose freshness or even rot, necessitating discounted sales or outright losses. This further inflates inventory costs and erodes profits. Analysis reveals the following root causes.

4.1.1 Severe inventory backlog

D Supermarket currently does not employ different ordering models tailored to the characteristics of various fresh produce items, frequently resulting in product inventory backlogs. The primary cause of D Supermarket's excessive fresh produce inventory is over-ordering, which frequently creates mismatches and imbalances between supply and demand for fresh items. Unlike general merchandise, fresh produce differs significantly in that its freshness and value are not static—they gradually decline over time. Consequently, when selecting fresh products, consumers consider not only the selling price but also the item's freshness. Based on the analysis of data from on-site surveys and inventory records provided by Supermarket D, demand information for 50 fresh produce items was compiled. It was discovered that at the end of the sales period, a substantial surplus of fresh produce remained, with inventory levels consistently exceeding demand. This inventory buildup necessitates Supermarket D to reduce losses through price promotions. Fresh produce exceeding its shelf life or expiration date must be forcibly removed from shelves, resulting in additional unnecessary costs for the supermarket.

4.1.2 Management of fresh produce is lax, lacking distinction between primary and secondary items

Inventory management for fresh produce requires meticulous handling tailored to its specific characteristics. However, D Supermarket's approach to fresh produce management appears overly simplistic and lacks prioritization. Particularly concerning high-value fresh items, the supermarket fails to allocate sufficient attention and emphasis. Furthermore, D Supermarket disproportionately allocates inventory costs toward storing lower-value fresh products, while demonstrating insufficient awareness of the need for differentiated management based on varying levels of perishability.

4.2 Excessive loss

Based on the analysis of current loss rates, it was found that the loss rate for a significant portion of fresh produce exceeds the supermarket's stipulated 5% tolerance, resulting in excessively high loss costs and increased inventory expenses. Fresh produce is characterized by diverse varieties, strong seasonality, and susceptibility to spoilage. To maintain freshness, supermarkets must equip specialized refrigeration and preservation facilities for product storage while also hiring professional inventory management technicians for meticulous stock control. However, D Supermarket currently suffers from a severe shortage of specialized equipment and relies on limited inventory management methods. Inventory management for all categories of fresh produce sold in the supermarket is based solely on individual staff experience, presenting significant drawbacks. Management approaches are not differentiated by product category, resulting in a large volume of fresh produce being unsuitable for the existing inventory management methods. This leads to spoilage, where issues such as rotting, discoloration, and off-odors in fresh produce cannot be effectively addressed. Fresh produce lacks guarantees of "safety" and "environmental sustainability." Vast quantities of spoiled and discarded fresh goods result in substantial direct economic losses, leading to severe inventory cost overruns.

4.3 Unreasonable ordering strategy

Currently, D Supermarket has not established distinct ordering models tailored to the characteristics of different fresh produce items. This hinders effective classification and management of fresh products. The irrational and unscientific categorization of fresh goods significantly impacts the supermarket's ordering decisions. During procurement, D Supermarket fails to consider the variety and shelf life of fresh produce. Most products are ordered either daily or every other day, frequently resulting in excessive orders or spoilage near the expiration date. Over 85% of D Supermarket's fresh produce losses stem from expired items being removed from shelves, highlighting a lack of scientific ordering strategies. Analysis reveals the following root causes:

4.3.1 Lack of detailed categorization for fresh produce

D Supermarket's current fresh produce ordering decisions lack sufficient understanding of product characteristics, fail to incorporate dynamic market responsiveness, and lack support from a more scientific procurement decision-making system. They do not employ professional techniques to perform standardized ABC classification based on metrics such as inventory quantity and value for fresh products. For high-value, short-shelf-life fresh items, failure to sell them promptly results in significant losses for the supermarket. Analysis of D Supermarket's current fresh produce inventory management reveals weak awareness of product classification. The supermarket fails to implement precise categorization for fresh items and lacks scientific selection and decision-making for ordering methods and quantities of high-value, short-shelf-life products.

4.3.2 Employee decision-making is largely subjective

D Supermarket is unable to accurately predict and assess consumer demand and inventory fluctuations for fresh produce. When determining fresh produce order quantities, staff primarily rely on past ordering experience, combining it with the item's sales volume during the same period and recent sales figures. However, this approach lacks a scientific, clear methodology. Relying on manual experience increases the risk of inaccurate order quantity forecasts. This can lead to over-ordering, causing inventory buildup, or under-ordering, resulting in product shortages that fail to meet market demand, thereby damaging the supermarket's operating profits. Since D Supermarket primarily relies on operational staff experience to compile ordering data for fresh produce, and given the difficulty of conducting timely inventory counts due to the wide variety of items, certain categories of fresh produce are frequently over-ordered or under-ordered. This results in excessively high spoilage costs or stockout costs, significantly reducing operating profits.

4.3.3 Inadequate inventory management systems and ineffective implementation and oversight

Employees at Supermarket D lack understanding of the characteristics of fresh produce, making it difficult for them to adhere to established standards in operations and management. Furthermore, the supermarket lacks a comprehensive inventory management system, leaving employees without clear guidelines or standards to follow. Fresh produce is neither properly categorized nor subject to regular stock counts, and inadequate inventory methods lead to over-ordering or under-ordering of the diverse range of fresh items. Additionally, management approaches for both new and experienced staff are inconsistent. There is no systematic training program for new employees, and the absence of an effective oversight mechanism makes it difficult to promptly monitor and correct employee errors. This hinders continuous improvement and impedes efforts to enhance the supermarket's operational efficiency.

5.Inventory Management Recommendations

5.1 Implement a differentiated ordering strategy

To optimize inventory management for fresh produce, a differentiated ordering strategy should first be developed based on product characteristics. For instance, fresh products have short shelf lives and strong time-sensitivity, necessitating precise management according to their sales cycles, demand fluctuations, and storage conditions. Employing the ABC classification method allows products to be categorized into tiers based on factors like sales volume, demand volatility, and shelf life, enabling more targeted inventory control. For high-value, short-shelf-life fresh goods, adopt a strategy of frequent, small-batch procurement while continuously monitoring inventory levels to prevent product spoilage from excessive stockpiling. Conversely, for low-value fresh goods with extended shelf lives, inventory levels can be appropriately increased while maintaining strict control over inventory turnover. This ensures meticulous inventory management and prevents waste. Through this differentiated approach, unnecessary inventory pressure is reduced, products reach the market at optimal times, and overall operational efficiency is enhanced.

5.2 Optimize inventory management processes to enhance precision management

First, establish a scientific inventory management system with differentiated standards for various product types. For high-value, short-shelf-life fresh goods, implement stricter freshness preservation and sales monitoring mechanisms to ensure product quality and prevent waste. Concurrently, low-value products with extended shelf lives can follow standard storage and rotation cycles to minimize inventory space utilization. Implementing an intelligent inventory management system, leveraging data analytics and market trend forecasting, enables more precise automated ordering. This reduces uncertainty from manual decision-making and prevents inventory buildup caused by market demand fluctuations or inaccurate sales

projections. For perishable goods, supermarkets should increase investments in refrigeration and freezing equipment while conducting regular operational checks to ensure temperature control remains consistent, thereby maximizing the quality and freshness of fresh produce. Furthermore, integrating real-time inventory data enables more effective optimization of restocking schedules, ensuring each category of fresh products enters the market at the optimal time for timely sales.

5.3 Enhance employee training and supervision mechanisms

Provide systematic training for employees, particularly regarding the characteristics of fresh produce and inventory management procedures. Training content should cover knowledge in inventory monitoring, ordering decisions, product categorization, and loss control to ensure staff can accurately assess the management requirements of different products. Establish a rigorous oversight mechanism to guarantee the implementation of inventory management protocols. Conduct regular internal inspections and physical counts to minimize human error and management oversights. Assign dedicated personnel to inspect and document each inventory transaction to ensure data accuracy.

5.4 Implement dynamic loss warning and control

Monitor fresh produce losses in real time through data analysis, establishing a loss alert system to promptly identify products nearing expiration or at risk of spoilage, enabling proactive measures. Conduct categorized analysis of fresh produce losses, implementing separate management and review for high-loss items to pinpoint root causes and implement improvements. Introduce automated restocking systems and more efficient logistics management to ensure products reach stores at optimal times for timely sales, reducing inventory backlog.

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