WEP Warwick Evans Publishing

Academic Journal of Management Science and Engineering

ISSN: 3080-9827 (Print), ISSN: 3080-9835 (Online) | Volume 1, Number 3, Year 2026
DOI: https://doi.org/10.62051/ajmse.v1n3.05
Journal homepage: https://ajomse.com



Optimization of Fresh Inventory Management in Xinyue Laike Supermarket Based on ABC Classification and a Perishable EOQ Model

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ABSTRACT

Fresh products are difficult to manage because they are perishable, demand changes quickly, and losses are strongly affected by storage and purchasing decisions. Taking Xinyue Laike Supermarket as a case, this paper rewrites the original thesis into a concise academic article. The study first identifies the main problems in the supermarket, including traditional inventory management, subjective ordering, high fruit loss rates, weak demand forecasting, and insufficient supplier cooperation. It then proposes an optimization framework based on ABC classification, a perishable-goods EOQ pricing model, particle swarm optimization, exponential smoothing, and supplier collaboration. The rewritten framework shows that high-value fruits should be controlled strictly, medium-value fruits should be supported by demand forecasting, and low-value fruits should be managed through stable cold-chain cooperation and simplified replenishment rules. The research provides a practical and operable method for reducing fruit inventory cost and improving fresh-food inventory efficiency in small supermarkets.

KEYWORDS

Fresh Products; Inventory Optimization; ABC Classification; Perishable Goods; EOQ Model; Particle Swarm Optimization.

1. INTRODUCTION

With the development of fresh-food retail, consumers have higher requirements for freshness, variety, safety, and delivery speed. Compared with ordinary daily commodities, fresh products have short shelf lives and are sensitive to temperature, humidity, storage conditions, and sales speed. If the ordering quantity is too large, deterioration and capital occupation will increase; if the ordering quantity is too small, shortages will reduce customer satisfaction. Therefore, inventory management has become a key issue for small and medium-sized fresh-food supermarkets [1,3].

Xinyue Laike Supermarket is a small community supermarket whose main fresh products include fruits, vegetables, meat, dairy products, and other daily food items. Its operation depends mainly on offline sales, while online sales play a supplementary role. The original thesis discussed the supermarket from five chapters, including research background, theoretical basis, current situation, model construction, and conclusions. In order to make the work closer to the form of a short academic paper, this rewritten version keeps only the core logic: problem identification, model design, solution method, and management suggestions.

The purpose of this paper is to build a simplified but complete optimization framework for fruit inventory management. Specifically, the paper classifies fruit items by ABC classification, constructs a perishable inventory and pricing model, uses an intelligent algorithm to search for better ordering

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decisions for high-value products, and proposes differentiated management measures for different fruit categories.

2. CURRENT SITUATION AND MAIN PROBLEMS

At present, Xinyue Laike Supermarket still uses a traditional inventory management mode. The supermarket mainly relies on staff experience to decide how much to purchase and when to replenish. This mode is simple and easy to operate, but it also causes inaccurate inventory records, weak process control, and excessive dependence on manual judgment. Because there is no complete inventory information system, the supermarket cannot quickly identify overstock, shortage, slow-moving goods, or abnormal losses.

The ordering mode is also relatively subjective. In many cases, the purchase quantity is determined according to the previous sales cycle. For example, if a certain fruit sold well last time, the next purchase quantity may be increased directly. This decision rule ignores seasonality, price sensitivity, deterioration rate, and supplier delivery stability. As a result, some products may be overstocked while others may be out of stock.

Fruit loss is another important problem. The original data show that several fruits have loss rates higher than the commonly acceptable level of about 5%. For example, Red Fuji apples, Kyoho grapes, watermelons, and blueberries all show relatively high loss rates. These losses are related to deterioration, slow turnover, poor storage conditions, water evaporation, transportation damage, and delayed discount decisions. In addition, the supermarket has not established a stable supplier evaluation mechanism, so supplier quality, delivery time, and cold-chain service cannot be effectively controlled [6].

Based on the above analysis, the key problem is not only that inventory cost is high, but also that the supermarket lacks a differentiated management framework. Different fruits have different values, demand characteristics, and deterioration risks. A unified ordering strategy is therefore not suitable. The following section proposes a classification-based optimization model to solve this problem.

3. OPTIMIZATION FRAMEWORK AND MODEL

3.1. ABC Classification Strategy

ABC classification is used to divide fruits according to their inventory value and management importance. In the case of Xinyue Laike Supermarket, blueberries and durians are classified as Class A products because they account for a high proportion of inventory value. Strawberries, cherries, and Red Fuji apples are classified as Class B products. Hami melons, Kyoho grapes, passion fruits, plums, and bananas are classified as Class C products [5].

According to this classification, Class A products should receive strict control, frequent inventory checks, and quantitative optimization. Class B products should be managed through demand forecasting and moderate control. Class C products account for a relatively low value share, so they can be managed with simplified replenishment rules and supplier cooperation. This classification reduces management complexity and allows the supermarket to focus resources on the most important items.

3.2. Perishable Inventory and Pricing Model

Because fruits deteriorate over time, the model considers both demand and deterioration. Let I(t) denote the inventory level at time t, theta(t) denote the deterioration rate, and D(t) denote the demand rate. The relationship among inventory, deterioration, and demand can be written as [1,2,3]:

$dI(t)/dt + \theta(t)I(t) = -D(t)$

The deterioration rate follows a three-parameter Weibull form [2,8]:

$\theta(t) = \alpha \beta (t - \gamma)^{(\beta - 1)}$

where alpha is the scale parameter, beta is the shape parameter, and gamma is the location parameter. The model also assumes that demand is affected by price. When the selling price decreases, demand increases; when the selling price increases, demand decreases. The price-dependent demand function is expressed as:

$D(p) = A \exp(-\lambda p)$

where A represents the maximum potential demand and lambda represents the price sensitivity coefficient. In one ordering cycle, products are sold at the original price before a certain time point and then sold at a discounted price after deterioration becomes significant. This setting reflects the actual practice of discounting fresh products before they lose sales value [4,7,8].

The ordering cost, holding cost, total cost, revenue, and profit are defined as follows:

$C_c = K + C_1 Q$

$C_h = C_2 \int_0^T I(t)\, dt$

$T_c = C_c + C_h, \qquad \pi = T_r - T_c$

The optimization objective is to maximize the profit pi by selecting a reasonable order quantity Q, selling price p, and ordering cycle T. Compared with experience-based ordering, this model links replenishment decisions with product deterioration and market demand, making the decision process more quantitative and systematic [3,4].

3.3. Solution Method

For Class A fruits, the model can be solved by particle swarm optimization. Each particle represents a possible combination of decision variables such as order quantity, price, and ordering cycle. The algorithm updates particle positions and velocities according to individual and global best solutions, and gradually searches for a better profit value. The original thesis used blueberries and durians as examples and showed that the objective value became stable after several iterations, indicating that the solution process had a certain convergence effect.

For Class B fruits, the paper introduces demand forecasting instead of complex optimization. Exponential smoothing can be used because it is easy to operate and suitable for short-term demand adjustment. In the original example, cherry demand was forecasted from recent sales data, and the next-period demand was estimated to be about 101.55 kg. This result can provide a direct reference for the next procurement decision.

For Class C fruits, the main goal is not complex modeling but process improvement. Because these fruits are numerous and have relatively low value shares, the supermarket should improve supplier cooperation, cold-chain transportation, and basic storage management to reduce unnecessary losses.

4. APPLICATION AND MANAGEMENT SUGGESTIONS

4.1. Strict Control for Class A Fruits

Class A fruits such as blueberries and durians occupy a large amount of inventory funds. Small changes in demand or loss rate may have a significant effect on profit. Therefore, the supermarket should adopt strict inventory control for these products. First, purchase quantity and ordering cycle should be calculated according to the perishable EOQ model rather than decided only by experience.

Second, daily inventory records should be strengthened so that deterioration and slow sales can be detected early. Third, dynamic discounting should be applied before deterioration becomes serious, which can reduce waste and improve cash recovery.

4.2. Forecasting Support for Class B Fruits

Class B fruits have medium inventory value and relatively stable sales. For this category, the supermarket does not need overly complex algorithms, but it should use basic forecasting tools. Exponential smoothing, moving average, or simple seasonal adjustment can be used according to historical sales records. The supermarket should also update forecasts weekly and adjust procurement quantities according to weather, holidays, promotions, and community consumption habits. This can reduce the gap between actual demand and purchase quantity.

4.3. Process Improvement for Class C Fruits

Class C fruits are many in quantity but account for a small proportion of inventory value. For these products, the key is to simplify management and reduce process losses. The supermarket should cooperate with stable suppliers, evaluate suppliers regularly, and establish clear standards for fruit quality, delivery time, packaging, and cold-chain conditions. It should also improve storage and display conditions, accelerate turnover, and use small-batch frequent replenishment when demand is uncertain.

4.4. Integrated Optimization Path

The overall optimization path can be summarized as follows. First, classify fruits by ABC analysis and determine management priority. Second, apply the perishable EOQ pricing model and particle swarm optimization to high-value products. Third, use short-term demand forecasting for medium-value products. Fourth, improve supplier cooperation and cold-chain processes for low-value products. Finally, build a simple inventory data recording mechanism so that future decisions can be based on sales data, loss data, and supplier performance rather than only personal experience.

5. CONCLUSION

This paper rewrites the original thesis into a concise academic article by following a short-paper structure. Taking Xinyue Laike Supermarket as the research object, it identifies the main problems in fresh fruit inventory management and proposes a differentiated optimization framework. The framework combines ABC classification, a perishable inventory and pricing model, particle swarm optimization, exponential smoothing, and supplier cooperation.

The main conclusion is that fresh inventory optimization should not use a single management rule for all products. Class A fruits require strict quantitative control because of their high inventory value. Class B fruits require demand forecasting to reduce ordering errors. Class C fruits require simplified management and supplier collaboration to reduce process losses. Through these measures, the supermarket can reduce deterioration losses, lower inventory cost, improve turnover efficiency, and make ordering decisions more scientific.

There are still limitations. The model assumes immediate delivery and does not consider shortages, emergency replenishment, or sudden demand fluctuations. Future research can further include uncertain lead time, seasonal demand, consumer behavior, and real-time inventory data to improve the accuracy and applicability of the model.

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