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Research on "Last Mile" Green Distribution Scheduling of Fresh E-commerce and Coordination Strategy of Pre-warehouse Inventory

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ABSTRACT
With the continuous expansion of the market scale of fresh e-commerce, the "last mile" distribution and pre-storage management have become the core links that determine the success or failure of its operation. This study focuses on this field and deeply analyzes the coordination strategy between green distribution scheduling and pre-warehouse storage. In the aspect of green distribution scheduling, factors such as vehicle route optimization, distribution time window setting and application of new energy vehicles are comprehensively considered to reduce distribution costs, reduce environmental pollution and improve distribution efficiency. Aiming at the coordination of pre-warehouse, this paper starts with inventory classification management, replenishment strategy formulation and inventory layout optimization, and strives to reduce the inventory holding cost while ensuring the freshness and supply stability of fresh products. Through systematic research, it will provide scientific and effective strategic reference for fresh e-commerce enterprises, help them build a sustainable logistics system in the fierce market competition and enhance their comprehensive competitiveness.

KEYWORDS
fresh e-commerce; The last mile; Green distribution scheduling; Pre-warehouse; Inventory coordination

1 Introduction

In recent years, fresh e-commerce has been favored by consumers because of its convenience and rich product types, and its market scale has exploded. However, the unique characteristics of fresh products, such as perishable and short shelf life, have brought unprecedented challenges to logistics distribution and inventory management. As a key link between consumers and e-commerce platform, "last mile" distribution has a direct impact on consumers' shopping experience and satisfaction. At the same time, as an important storage base of fresh products near the sales place, how to scientifically and reasonably coordinate the inventory to ensure the fresh supply of products and control the cost has become a key problem for the operation of fresh e-commerce. In this context, it is of great practical significance and theoretical value to deeply explore the "last mile" green distribution scheduling and pre-storage coordination strategy of fresh e-commerce, which can not only provide an effective path for fresh e-commerce enterprises to solve the actual operational difficulties, but also promote the whole industry to develop in a green, efficient and sustainable direction.

2 The "last mile" green distribution scheduling strategy of fresh e-commerce

2.1 Vehicle Path Planning Based on Optimization Algorithm

In the "last mile" distribution of fresh e-commerce, vehicle path planning directly affects the distribution efficiency and cost. The traditional manual planning method is difficult to cope with the complicated and changeable order demand and traffic conditions. Using advanced optimization algorithms, such as genetic algorithm and ant colony algorithm, the optimal vehicle driving path can be generated according to multi-dimensional information such as order position, delivery time requirements and vehicle cargo capacity. Genetic algorithm simulates the biological genetic evolution process, selects, crosses and mutates path combinations, and iteratively optimizes them to find the global optimal solution. Ant colony algorithm makes use of the characteristics of pheromone released by ants in the process of searching for food, so that vehicles can choose the path according to the pheromone concentration in the path search. As the search progresses, pheromones are constantly updated, guiding vehicles to gradually find the optimal path. Through these optimization algorithms, vehicle mileage can be effectively reduced, fuel consumption and carbon emissions can be reduced, the loading rate of distribution vehicles can be improved, and the phenomenon of circuitous driving and no-load can be avoided, thus improving distribution efficiency and reducing distribution costs.

2.2 Dynamic Time Window Distribution Strategy

Fresh products require extremely high delivery timeliness, and delivery time too early or too late may lead to product quality degradation or poor customer experience. The dynamic time window distribution strategy flexibly adjusts the distribution time window according to the real-time status of the order, the expected receiving time of the customer and

the traffic conditions. At the initial stage of order generation, the system initially sets a time window according to the customer's expected receiving time and historical delivery experience. During the delivery process, the vehicle position and speed are monitored in real time, and combined with the road information, if there is traffic jam, the system will automatically re-evaluate the delivery time, adjust the time window, and notify the customer in time.

2.3 Application of new energy vehicles and construction of supporting facilities

In order to achieve the goal of green distribution, fresh e-commerce enterprises should increase the proportion of new energy vehicles in the "last mile" distribution. New energy vehicles, such as electric vehicles and hybrid vehicles, have the advantages of zero or low emissions compared with traditional fuel vehicles, which can significantly reduce environmental pollution in the distribution process. However, the promotion and application of new energy vehicles are facing problems such as limited cruising range and long charging time. Therefore, on the one hand, fresh e-commerce enterprises need to cooperate with automobile manufacturers to develop new energy vehicles suitable for fresh delivery scenarios and improve vehicle endurance and cargo space; On the other hand, we should actively promote the construction of charging infrastructure. Cooperate with relevant departments and enterprises to build charging piles, power stations and other facilities in distribution centers, pre-warehouses and major distribution nodes in the city.

3 The pre-warehouse inventory classification management strategy

3.1 ABC classification based on product characteristics

There are many kinds of fresh products stored in the front warehouse, and there are great differences in shelf life, sales speed and value among different products. Using ABC classification method, inventory can be classified and managed according to product characteristics. Fresh products with large sales volume, short shelf life and high value, such as fresh meat and seafood, are classified as Class A products. This kind of products are high-frequency products purchased by customers, which require extremely high freshness. It is necessary to focus on inventory dynamics and adopt the principle of first-in-first-out inventory management to ensure that the products are sold as soon as possible within the warranty period. Class B products are commodities with moderate sales volume, relatively long shelf life and medium value, such as some vegetables and canned fruits. The inventory management accuracy can be slightly lower than that of Class A products, but it still needs regular inventory and replenishment. Class C products are commodities with small sales volume, long shelf life and low value, such as condiments, dry goods, etc., which can appropriately increase inventory batch, reduce replenishment times and reduce inventory management costs. Through ABC classification, different kinds of fresh products are managed differently to improve the pertinence and efficiency of inventory management.

3.2 Shelf life segmented management mode

The shelf life of fresh products is a key factor affecting their quality and sales. Pre-warehouse can adopt the management mode of shelf life segmentation, divide the shelf life of products into multiple stages, and formulate corresponding inventory management measures for different stages. At the initial stage of product warehousing, before the shelf life, the inventory quantity can be appropriately increased to meet the demand during the peak sales period. As time goes by, enter the middle of the shelf life, pay close attention to product sales, adjust the inventory level according to the sales speed, and take timely promotion measures to speed up shipment if the sales are slow. When the product enters the latter part of the shelf life and approaches the expiration time, the remaining inventory can be cleaned up, and the loss can be reduced as much as possible by means of substantial price reduction and combined sales.

3.3 Differentiation strategy of high turnover and low turnover products

According to the turnover rate of fresh products, they are divided into high turnover products and low turnover products, and differentiated inventory management strategies are implemented. High turnover products, such as common leafy vegetables, eggs, etc., have a fast sales speed and relatively small fluctuations in demand. For this kind of products, the front warehouse should maintain a high inventory level to ensure the continuity of supply. By establishing close cooperation with suppliers, we can realize rapid replenishment and shorten the replenishment cycle to cope with the possible demand peak. Low turnover products, such as some imported fruits, specialty fresh food, etc., have a slow sales speed and the demand is uncertain.

For this kind of products, the pre-warehouse should strictly control the inventory quantity, and adopt the replenishment method of small batch and multi-batch to avoid inventory backlog.

4 The pre-warehouse storage and replenishment strategy

4.1 Construction of replenishment model based on demand forecast

Accurate demand forecast is the basis of reasonable replenishment of the front warehouse. Using big data analysis technology, combined with historical sales data, seasonal factors, holidays, weather changes and market trends and other information, a demand forecasting model is built. Commonly used forecasting methods include time series analysis, regression analysis, machine learning algorithm and so on. Time series analysis predicts future demand by analyzing the trend, period and seasonal changes of historical sales data. Regression analysis finds out various factors that affect the demand of fresh products, such as price and promotion activities, and establishes a mathematical relationship model between demand and these factors to predict demand. Machine learning algorithms, such as neural networks and decision trees, can deal with complex nonlinear data, mine potential laws in the data and improve the accuracy of prediction. Based on these forecasting models, the pre-warehouse can plan the replenishment quantity and time in advance to avoid the shortage phenomenon caused by insufficient inventory, which will affect the customer experience, and at the same time prevent the overstock waste caused by excessive inventory and reduce the inventory cost.

4.2 Safety stock setting and dynamic adjustment

In order to cope with uncertain factors such as demand fluctuation and replenishment delay, the front warehouse needs to set up a safety stock. The setting of safety stock is not static, but should be dynamically adjusted according to the actual operation. Consider the fluctuation of product sales, the reliability of suppliers' delivery and the uncertainty in the distribution process. For fresh products with large fluctuations in sales and unstable delivery by suppliers, the level of safety inventory should be appropriately improved; For products with relatively stable sales and reliable supply chain, safety inventory can be reduced. At the same time, using real-time inventory data and sales data, the inventory level is monitored in real time through the information system. When the inventory is lower than the safety inventory warning line, the system automatically triggers the replenishment process. In addition, with the change of market environment, promotion activities and seasonal changes, the safety stock is re-evaluated and adjusted regularly to ensure that the safety stock can effectively guarantee the supply and will not occupy too much capital and storage space.

4.3 Collaborative replenishment mechanism and supplier cooperation optimization

Establishing a collaborative replenishment mechanism between the front warehouse and suppliers can improve the replenishment efficiency and reduce the supply chain cost. Both parties share sales data, inventory information and replenishment plan, so as to realize real-time interaction and transparency of information. According to the inventory and sales situation of the front warehouse, the supplier actively participates in the replenishment decision, arranges production and distribution in advance, and shortens the replenishment cycle. At the same time, by signing a long-term cooperation agreement with suppliers, the rights and obligations of both parties in the replenishment process are clarified, and a stable cooperative relationship is established. In the process of cooperation, we will constantly optimize the cooperation process and jointly explore ways to reduce costs and improve service quality. For example, jointly carry out inventory management training to improve the professional level of inventory management personnel of both parties; Jointly develop packaging and transportation methods suitable for fresh products to reduce the loss of products during transportation and storage. Through collaborative replenishment mechanism and supplier cooperation optimization, the mutual benefit and win-win situation between the front warehouse and the supplier can be realized, and the stable supply of fresh products can be guaranteed.

5 The optimization strategy of pre-warehouse storage layout

5.1 Storage Area Planning and Functional Zoning

Reasonable planning of storage area and functional partition of pre-warehouse can improve warehouse space utilization and operation efficiency. According to the characteristics of fresh products, the warehouse is divided into different temperature and humidity storage areas such as cold storage area, frozen area and normal temperature area to ensure that all kinds of products are stored in suitable environment and prolong the shelf life. In each storage area, functional areas are further subdivided, such as warehousing temporary storage area, storage area, sorting area, packaging area and delivery area. The warehousing temporary storage area is used to temporarily store newly arrived products, which is convenient for acceptance and warehousing operations; In the storage area, the shelf layout is carried out according to the product category, turnover speed and other factors, and the high turnover products are placed near the sorting area to reduce the handling distance; The sorting area is equipped with professional sorting equipment and

tools to improve the efficiency of order sorting; The packaging area is responsible for the secondary packaging of products to ensure the safety of products in the distribution process; The delivery area is used for centralized storage of the ordered goods to be delivered, which is convenient for vehicle loading and distribution. Through scientific and reasonable storage area planning and functional zoning, the warehouse operation process is optimized and the overall operation efficiency is improved.

5.2 Shelf Layout and Goods Placement Principles

Shelf layout and goods placement are equally important to the inventory management of the front warehouse. Select appropriate shelf types, such as beam shelf, gravity shelf, fluent shelf, etc., and configure them according to the size, weight and storage requirements of products. The beam shelf is suitable for storing fresh products of various specifications and has strong versatility; Gravity shelves and fluent shelves use the principle of gravity to realize the first-in and first-out of goods, which is suitable for storing products with short shelf life and fast turnover speed. In terms of goods placement, the principles of classified storage, corresponding weight and first-in first-out are followed. Products of the same category are stored in adjacent shelves, which is convenient for management and search; The heavier products are placed at the bottom of the shelf, and the lighter products are placed at the top to ensure the stability and safety of the shelf; According to the time sequence of product warehousing, put the products that are put into storage first in an easy-to-take-out position to ensure FIFO and prevent the products from being out of date and deteriorating.

5.3 Inventory space utilization and vertical expansion

In the case of limited land resources and rising storage costs, making full use of the storage space of the front warehouse, especially vertical expansion, has become an important means to improve storage efficiency. By installing high-rise shelves and using lifting equipment, the vertical storage layers of the warehouse are increased, and the storage capacity per unit area is effectively improved. At the same time, the ceiling height and channel width of the warehouse should be designed reasonably, and the vertical space should be used to the maximum extent on the premise of ensuring the normal operation of cargo handling equipment.

6 Summary

This study focuses on the "last mile" green distribution scheduling of fresh e-commerce and the coordination of pre-warehouse storage, and puts forward a series of targeted and feasible strategies. In the aspect of green distribution scheduling, vehicle routing planning with the help of optimization algorithm, dynamic time window distribution strategy and vigorously promoting the construction of new energy vehicles and supporting facilities can effectively improve distribution efficiency, reduce costs and reduce environmental pollution. In the inventory management of pre-warehouse, inventory classification management is realized through ABC classification based on product characteristics, shelf life segmentation management mode and differentiation strategy of high turnover and low turnover products; Use the replenishment model based on demand forecast, the setting and dynamic adjustment of safety inventory and the collaborative replenishment mechanism to cooperate with suppliers to optimize and improve the inventory replenishment strategy.

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