Slotting Optimization of Distribution Center for Agriculture Products Considering "Freshness" under Traceable Cold Chain

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Abstract

With the rapid development of logistics, trade, and people's pursuit of health, the demand for fresh and safe fresh products is increasing, and logistics providers are facing great challenges. Distribution is an important part of fresh food delivery from the origin to the dining table, and its operation efficiency and service level are very important. Since the actual freshness of fresh products will be different due to the different operation conditions of different logistics links from the origin to the cold storage of distribution center, the purpose of this study is to explore the freshness evaluation method of fresh products, and to optimize the operation of the distribution center in the later stage by tracing the logistics operation information in the early stage. First of all, for a fresh product, the concentration of CO_2 in the closed environment at different temperatures was measured. The respiration rate was calculated, and then the freshness decline rate of fresh products at different temperatures was obtained. Secondly, the system flow chart of fresh products from picking, packaging, precooling, transportation, loading and unloading and handling is constructed, and the freshness is taken as the system reliability. Through the information traceability of the early temperature and operation time, the freshness rating of fresh products before warehousing is completed based on GO-FLOW method. Finally, taking the overall freshness, warehousing efficiency and shelf stability of cold storage as indicators, a multi-objective location optimization model is constructed, and the location allocation scheme is obtained through NSGA-II algorithm, which makes it more convenient for "perishable and perishable" fresh products and fresh products with high turnover rate. This paper provides a new idea for fresh product freshness rating and fresh product distribution center location optimization research, which is of great significance for improving fresh product freshness, service level and competitiveness of distribution center.

Keywords

Freshness rating; GO-FLOW; Multi-objective programming; Location optimization; NSGA-II.

1. INTRODUCTION

Fresh food logistics distribution center is a link between the upstream agricultural production and downstream demanders. It undertakes the fresh-keeping storage, sorting, processing, packaging, distribution, food testing and other affairs of all kinds of fresh products. The objects of storage are fruits and vegetables, frozen aquatic products, dairy products, etc. such fresh products in an unreasonable external environment will affect the freshness and shelf life of the products, so they need to be stored in the appropriate conditions of cold storage,

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freezer and fresh-keeping warehouse. Research on the location allocation of fresh products in the warehouse of distribution center can improve the efficiency of warehousing and improve the service level of the distribution center, but it also faces many challenges. First of all, there are many kinds of fresh products, which are frequently put in and out of the warehouse; second, the freshness of fresh products is different, which is greatly affected by the external environment. For fruits and vegetables, from the place of origin to the distribution center, fresh products go through the logistics process of picking, precooling, packaging, loading and unloading, storage, long-distance transportation and so on. The early non-standard operation may lead to different freshness of fruits and vegetables. For fruits and vegetables with different freshness, we can not simply follow the first in first out rule. In the face of a large number of fruits and vegetables with different freshness and a wide variety, how to store them, and ensure that they are easy to be put into and out of the warehouse, and the loss rate is low is one of the challenges faced by fresh logistics distribution centers. Aiming at the category of fruits and vegetables, this paper first constructs the freshness evaluation method of fruits and vegetables due to the early logistics operation, and then constructs a multi-objective programming model considering the efficiency of warehousing and storage freshness to study the location allocation problem of fresh products distribution center warehouse, so as to improve the overall freshness and warehousing efficiency of the goods stored in the distribution center.

In recent years, scholars at home and abroad gradually realized the importance of location optimization, and discussed the storage optimization. Arjan S [1] pay attention to the comprehensive impact of path and storage location allocation on the performance of warehousing process, and determine the storage location allocation based on the shortest path formula and optimality attribute. Pan [2] et al. proposed a cargo location optimization model with the goal of picking staff's workload balance for fast delivery, multiple categories and small warehouses, and used genetic algorithm to solve the model to obtain an optimized location allocation strategy. Chao-Lung Yang [3] developed a constrained clustering method combined with principal component analysis to meet the needs of clustering storage items under consideration of actual storage constraints.

When goods are warehousing operations, how to allocate reasonable locations is usually complicated and restrictive, usually involving efficiency principles, relevance principles, and stability principles. Therefore, many scholars have constructed a multi-objective planning model for cargo location optimization research. Early Shang [4] et al. merged the concept of Pareto optimality into the genetic algorithm to solve the multi-objective allocation model. Chen [5] et al. proposed an improved particle swarm optimization to solve such problems and optimize cargo allocation. Subsequently, scholars used various improved intelligent algorithms such as simulated annealing algorithm, nested partition algorithm, firefly algorithm, greedy algorithm, and elite multi-strategy method to optimize the solution of multi-objective planning models such as cargo location allocation [6]-[10]. Cai [13] established a multi-objective location allocation model according to the principle of efficiency first and stability, and designed an integrated multi-objective genetic algorithm based on vector evaluation, non dominated sorting and niche Pareto theory to optimize the algorithm to adapt to any stage of the search process, which provided a new idea for the optimization of the location allocation model. In addition, with the development of technology, Xu [11] use data warehouse and data mining method to study the dynamic assignment strategy based on compound rules, which makes the allocation better in the case of large order scale and demand. Peng [12] based on the intelligent warehouse environment of manufacturing IOT technology, established a multi-objective allocation model considering multi rule constraints, and used the improved genetic algorithm to solve it. It can be seen that it has become the development trend of research on location optimization to build a model for warehouse demand and use intelligent algorithm to solve it.

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Most of the research focuses on the location optimization and algorithm improvement of general goods warehouse, but there is less research on the storage optimization of fresh goods, which is a special goods. Fresh goods have dynamic shelf life affected by the environment. The concept of shelf life is used to predict the quality of fresh products. There are usually some indexes used to determine the shelf life, including microbial index (such as the number of bacteria), physicochemical index (such as vitamin content), and sensory index (such as appearance, taste, texture), etc. For the "freshness" measurement, Rong [14] et al. used Arrhenius equation to calculate the remaining shelf life according to the change of time and temperature. Man [15] et al. established the model of time, temperature and other related factors to evaluate the quality degradation. Hertog [16] et al. introduced some models to estimate the quality change of fresh products and how to apply these models to the decision of “first putrefaction, first delivery” to optimize the storage process. It is complex to predict the shelf life of fresh products. Because of the different characteristics of each fresh product and the dynamic external environment, many scholars have studied the shelf life model of specific fresh products [17] [18].

2. PROBLEM ANALYSIS

2.1. Problem Description

The common cold chain logistics mode of fresh products in China is picking at the place of origin, short-distance transportation to the local cold storage for grading, precooling and packaging, long-distance transportation to the distribution cold storage for short-term storage, sorting and packaging, and distribution to the final consumption place. Since fresh products are more sensitive to the external environment, there are many risk factors in the logistics process of fresh products, such as long loading and unloading time, no pre-cooled in the place of production area, no fresh-keeping treatment in the place of production area, long transportation time, cold chain interruption, etc. (see Figure 1).

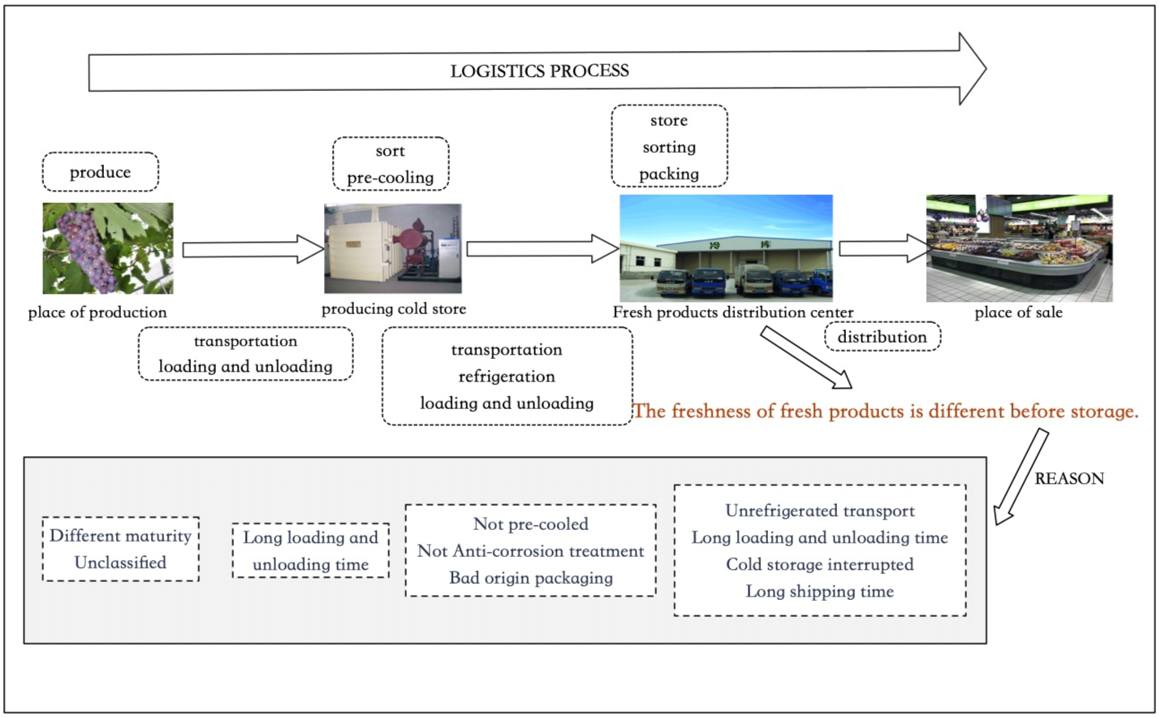

Figure 1. Cold chain logistics circulation process and risk factors

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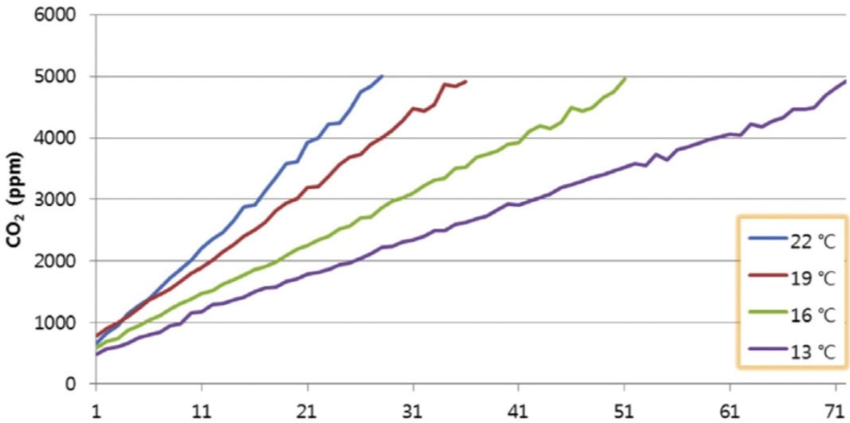
Therefore, due to the difference in the early logistics operations, the fresh products of the same variety will have different freshness when they arrive at the distribution center. It is not scientific to simply follow the "first in, first out of the warehouse" . Fresh products arriving late in the warehouse may be less fresh and perishable. Therefore, this article believes that it is more scientific to adopt the strategy of "first rot, first out of the warehouse", which can improve the freshness of the overall storage of the fresh food distribution center. Therefore, based on the two factors of freshness and storage efficiency, this paper constructs a multi-objective planning model to optimize the location, so that the fresh products with low freshness and high frequency of storage can be more conveniently stored in and out of storage.

2.2. Evaluation Method of "Freshness" Drop Weight

Freshness means that the product is very close to the production date and has not suffered too much contamination. Fresh agricultural products are freshest when they are just picked, and since then, the freshness has dropped to a stale state. The remaining freshness time can be used to measure the freshness. Vegetables and fruits can breathe, and fresh produce with a higher respiration rate has a faster decline in freshness. Fresh products have different breathing rates in different environments, and their preservation time is also dynamically changing, so this article chooses to calculate the preservation time based on the respiration rate. Since the breathing process ($C_6H_{12}O_6 + 6O_2 + 6H_2O \rightarrow 12H_2O + 6CO_2$) is accompanied by the discharge of CO_2 ,an experiment was designed to measure units at different temperatures in a confined space The concentration of carbon dioxide over time is used to obtain the respiration rate of fresh produce.

In summary, this article mainly uses the CO_2 emission rate to measure the freshness reduction weight, and then evaluate the freshness. For example, if the banana is placed in a refrigerated laboratory, the temperature interval is set to $3^{\circ}C$, and the concentration of CO_2 is measured every minute with a sensor, and the result is shown in Figure 2 below:



temperature（℃）	CO_2 emission rate（ppm/min）
13	58.98
16	84.48
19	121.19
22	161.47

Figure 2. CO_2 emission rate in banana experiment (Kim et al., 2012)

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The degree of decrease in freshness can be calculated by measuring the emission rate of CO_2, Firstly, calculate the average CO_2 emission rate in the temperature range; Secondly, since 13-16 degrees is the best storage temperature for bananas, it is assumed that the freshness of bananas is maintained at 100%; Use the ratio between the emission rate and the normal emission rate to estimate the freshness reduction weight of other temperature ranges, as shown in Table 1 below:

Table 1. Freshness reduction weight calculation

Temperature range (°C)	Average CO_2 emission rate (ppm/min)	Freshness reduction (%)	Freshness reduction weight
13-16	(58.98+84.48)/2=71.73	100	1
16-19	(84.48+121.19)/2=102.84	69.75	0.7
19-22	(121.19+161.47)/2=141.33	50.75	0.51

According to table 1, when bananas are stored at 13-16 °C, the fresh-keeping time is the maximum; when bananas are stored at 16-19 °C, the fresh-keeping time is 0.7 times of the maximum; when bananas are stored at 19-22 °C, the fresh-keeping time is 0.51 times of the maximum.

2.3. Freshness Evaluation Based On GO-FLOW Method

In order to ensure the safety and quality of fruits and vegetables, from picking to distribution centers, the pre-cooling of fruits and vegetables, loading and unloading, initial processing, storage, and transportation all require special cold chain logistics support (see Figure 3). Non-standard operations in various links may cause the freshness of fresh products to be different before entering the warehouse, such as excessive loading and unloading and handling time, non-precooling, non-refrigerated transportation, refrigeration interruption, and long transportation time.

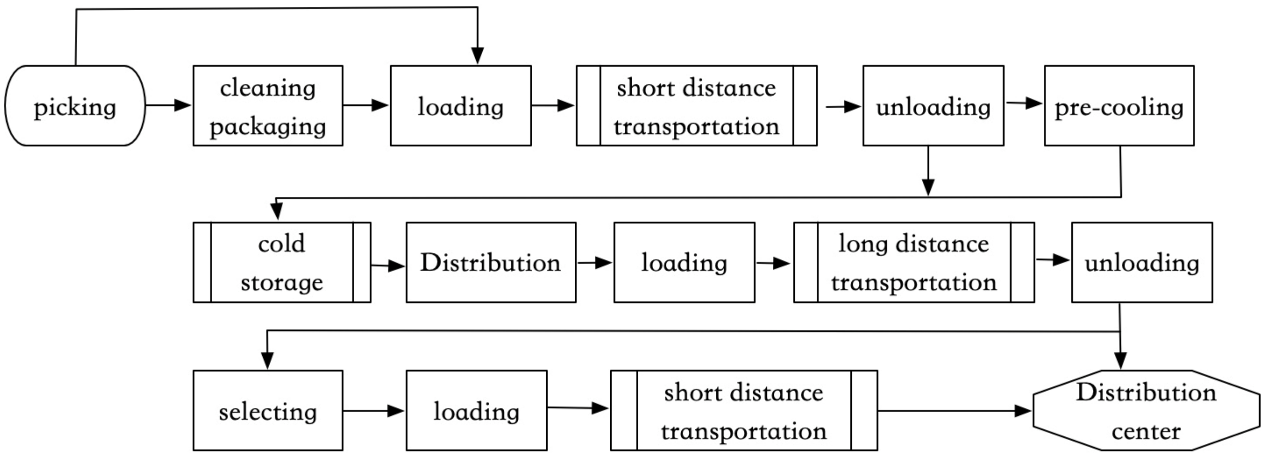

Figure 3. Overall structure diagram of fresh product logistics system

Since the freshness of agricultural products changes with time, the GO-FLOW method developed on the basis of the GO method is selected to evaluate the freshness. The GO-FLOW method is mainly used in systems where the system status changes with time. Taking the reliability of the system as the starting point, the operation principle diagram is transformed

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into the GO-FLOW model diagram, and the GO method program is used to calculate the probability of occurrence of various states. The GO-FLOW model diagram uses operators to represent the specific activity processes or components in the system, and uses signal flow to connect each operator to represent the logical transportation channel. The signal flow of the final system end component represents the reliability. The GO-FLOW method is mainly applicable to the reliability and safety analysis of systems with certain operating procedures, phased tasks, or state changes over time. This article takes the logistics activities of agricultural products from picking to the distribution center as a system, and uses the GO-FLOW method to rank freshness.

According to the overall structure diagram of the fresh product logistics system, the GO-FLOW diagram of the fresh product logistics system is obtained:

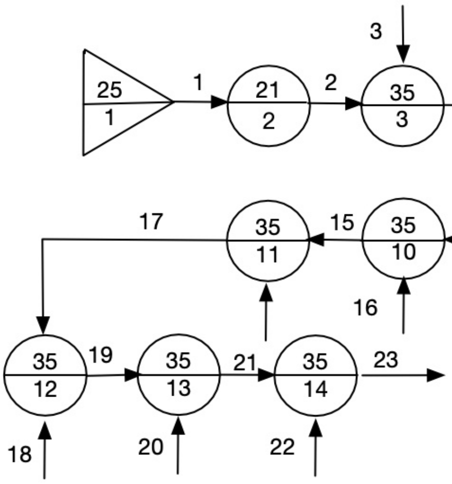

Figure 4. Fresh food logistics system based on GO-FLOW chart

When using the GO-FLOW method, the meaning of its signal flow and operators are as follows:

Signal flow: In the logistics process of fresh products, due to the influence of the external environment, their freshness may gradually decrease. Therefore, the intensity of the signal flow can indicate the freshness of fresh products. S(t) represents the input signal strength, and R(t) represents the output signal strength. The stronger the signal flow, the higher the freshness of the fresh products.

Operator: Harvesting is a signal generator (type 25), which represents the starting point of the cold chain of fresh products; cleaning, packaging, and pre-cooling are two-state components (type 21), which respectively indicate the operating status of the operator; short-distance transportation, Loading and unloading, refrigeration at the origin, long-distance transportation, etc. are working elements that fail over time (type 35), which means that the freshness decreases with time due to a long time.

In the GO-FLOW method, the operation rules and symbolic forms of operators are shown in the table:

Table 2. Symbolic meaning of corresponding operation rules in GO-FLOW method

symbol	meaning	symbol	meaning	symbol	meaning
λ_S	input failure	λ_R	output failure	λ_C	own failure
A_S	input	A_R	output	A_C	own

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Table 3. Corresponding operators and operation rules in GO-FLOW method

operator	algorithm
signal generator (type 25)	$A_R = A_C$
	$\lambda_R = \lambda_C$
two-state unit (type 21)	$A_R = A_S \times A_C$
	$\lambda_R = \lambda_S + \lambda_C$
Units of work that fail over time (type 35)	$A_R = A_S e^{-\lambda A_C}$

In this paper, the reliability of the GO-FLOW method is used to express the freshness of fresh products, so it is more reasonable to adopt formula 1 for work units that fail over time. In the formula, T represents the elapsed time of the work unit, S represents the longest freshness-keeping time of fresh products at a suitable temperature, and ω represents the weight of freshness reduction.

$$\boldsymbol{A_R = A_s - \frac{T}{S \times \omega}}$$

Table 4. Operation time and temperature information traceability table of early logistics activities

Number	Type	Unit name	Work time/h	Temperature/°C	λ_C
1	25	Picking	3	15	0
2	21	Cleaning Packaging	3	15	0.01/0.1
3	35	Loading	1.5	15	0.65
4	35	Short distance transportation	0.4	15	0.65
5	35	Unloading	0.6	15	0.65
6	21	Pre-cooling	0.6	0	0.005/0.1
7	35	Origin storage	48	2	1
8	35	Disturb	0.8	15	0.65
9	35	Loading	1.2	15	0.65
10	35	Long distance transportation	25	15	0.65
11	35	Unloading	2	15	0.65
12	35	Picking	0.3	15	0.65
13	35	Loading	0.2	15	0.65
14	35	Short distance transportation	0.6	15	0.65

The failure rate mainly reflects the deterioration of agricultural products and the decrease in freshness. According to the analysis of fresh products by researchers, the freshness attenuation of agricultural products in transportation and storage mainly depends on temperature, time and other variable factors. The increase in temperature can enhance the activity of some enzymes in the fruit, and accelerate the respiration rate of the fruit and the release rate of ethylene, thereby accelerating the loss of dry matter of the fruit. Secondly, the increase in temperature will speed up the reproduction rate of decaying microorganisms. If there are wounds on the surface of the fresh products, the microorganisms will easily invade the inside of the fresh products, thereby promoting the decay of the fresh products. Therefore, in the logistics process of fresh products, the most important control factor is temperature. With the development of the traceable cold chain, before fresh products arrive at the distribution center,

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they can trace the operation time and temperature information of the previous logistics activities (see Table 4), and use the "freshness" evaluation method proposed in this article to evaluate the freshness.

The failure rate of work units that fail over time is based on the "freshness" evaluation method, that is, the weight of the decrease in freshness at different temperatures. The cleaning and packaging and pre-cooling are two-state components, that is, whether they have been cleaned and packaged or whether they have been pre-cooled have a greater impact on freshness. The failure rate can be quantified based on the average accident rate at different temperatures. The types of accidents mainly include damage, decay and deterioration of agricultural products, etc. According to the previous research report, the freshness failure rate after cleaning, packaging and pre-cooling is 0.01, 0.005; if it is not packaged, the freshness will decrease by 0.1 after pre-cooling. Through the tracing of the previous logistics operation information, when the fresh products arrive at the distribution center, the freshness evaluation is based on GO-FLOW (see Table 5). According to the previous information, different operation processes have different failure rates. Table 5 records the process of an incomplete cold chain transportation. Fresh products are picked, graded at the origin, cleaned and packed, and transported to the cold storage at the origin for pre-cooling and storage, general transportation to the distribution center. Through the calculation of system reliability (freshness), it can also be found that when cold chain transportation is not used, the degree of freshness decreases greatly. When it finally arrived at the distribution center, the freshness of the fresh products was 0.783.

Table 5. Freshness evaluation based on GO-FLOW method

Operator		Operator signal		Output signal strength	Operator		Operator signal		Output signal strength
Number	Type	Input	Output		Number	Type	Input	Output	
1	25		1	1.0	9	35	13	15	0.956
2	21	1	2	0.990	10	35	15	17	0.796
3	35	2	4	0.980	11	35	17	19	0.783
4	35	4	6	0.977	12	35	19	21	
5	35	6	8	0.974	13	35	21	23	
6	21	8	9	0.969	14	35	23		
7	35	9	11	0.969	15				
8	35	11	13	0.964	16				

3. OPTIMIZATION MODEL OF FRESH PRODUCT LOCATION CONSIDERING "FRESHNESS"

3.1. Mathematical Model Hypothesis

When establishing the location allocation model, the following conditions are assumed:

(1) Each cargo space is the same size and one cargo space stores the same kind of goods

(2) Know the information of the goods that will be put into the warehouse the day before and know whether the storage space is empty

(3) The size of the goods is standard and stored in the pallet, and placed in the cargo space in the form of a pallet

(4) The forklift moves at a constant speed in the horizontal and vertical directions, regardless of the acceleration and deceleration process

(5) The working time required for entering and exiting the warehouse only considers the walking time of the forklift, and the time for turning the forklift and storing and storing goods is ignored.

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(6) The cargo position in the shelf is represented by three-dimensional coordinates. After the goods are placed in the cargo space, the center of the cargo is located at the geometric center of the cargo space.

3.2. Multi-objective Cargo Location Optimization Model Establishment

According to the freshness attribute of fresh products, the parameters of shelf and forklift, the turnover rate of goods, the stability of shelf and the principle of fresh products putrefying first and leaving the warehouse first, a multi-objective location allocation model of three-dimensional warehouse is established.

3.2.1 Improve the efficiency of goods in and out of storage

$$\boldsymbol{f_1(i_m, \mathrm{j}, t_r) = \min \sum_{i_m \in I} \sum_{j \in J} \sum_{t_r \in T} (x_{i_m j t_r}\, d^P_{i_m j})} \quad (1)$$

$$\boldsymbol{d^P_{i_m j} = \left| c_{i_m} - c_j \right|} \quad (2)$$

$x_{i_m j t_r}$ is a 0-1 decision variable. When $x_{i_m j t_r}$ is 1, it means that the goods i_m are stored in position j in the shift t_r; c_{i_m} is the turnover rate level of the goods in a shift, its definition is as follows: (1) Arrange the turnover rate of all items in ascending order; (2) Use the maximum and minimum values to get the turnover percentage ranking; (3) Divide all items into w grades according to the percentage, and make the goods i_m correspond to c_{i_m}. c_j is the level of cargo location j, which is determined according to the working hours of the forklift trucks accessing the cargo location j. The specific definition method is the same as above. $d^P_{i_m j}$ represents the difference between the level of cargo location j and the turnover rate of cargo i_m. The smaller the value, the more appropriate the allocation of cargo i_m to cargo location j.

3.2.2 Improve shelf stability

$$\boldsymbol{f_2(i_m, \mathrm{j}, t_r) = \min \left(\frac{minG_y + minG_z}{2} \right) \times x_{i_m j t_r}} \quad (3)$$

$$\boldsymbol{G_y = min \left| \frac{\sum_{x=1}^{m} \sum_{y=1}^{n} \sum_{z=1}^{q} (g_{j\in(x,j,z)} \times (y-0.5) l)}{g_{j\in(x,j,z)}} - 0.5 \times l \times n \right|} \quad (4)$$

$$\boldsymbol{G_z = min \frac{\sum_{x=1}^{m} \sum_{y=1}^{n} \sum_{z=1}^{q} (g_{j\in(x,j,z)} \times (z-0.5) h)}{g_{j\in(x,j,z)}}} \quad (5)$$

The three-dimensional warehouse has m rows, n columns and q layers. The length, width and height of the storage space are l, w and h respectively. The storage space j located in the x row, y column and z layer is (x, y, z).G_y, G_z, g_j represents the horizontal center of gravity, the vertical center of gravity of the shelf and the weight of the goods in position j on (x, y, z).

3.2.3 Improve the safety of fresh food storage

$$\boldsymbol{f_3(i_m, \mathrm{j}, t_r) = \min \sum_{i_m \in I} \sum_{j \in J} \sum_{t_r \in T} (x_{i_m j t_r}\, d^O_{i_m j})} \quad (6)$$

$$\boldsymbol{d^O_{i_m j} = \left| \mathrm{o}_{i_m} - c_j \right|} \quad (7)$$

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o_{i_m} is the freshness classification of the goods according to the different environments in which logistics operations, and the classification method is the same as above. $d_{i_m j}^{F}$ represents the difference between the level of the cargo location j and the freshness level of the cargo location i_m. The smaller the value, the lower the freshness of the fresh product can be placed in the cargo location away from the entrance and exit.

To sum up, the multi-objective mathematical model of fresh goods logistics distribution center location optimization can make the fresh goods freshness level match with the location level, the fresh goods in and out frequency match with the location level, and the overall center of gravity of the shelf is stable. The mathematical model can be described as follows:

$$\begin{cases} \min f_1(i_m, j, t_r) = \min \sum_{i_m \in I} \sum_{j \in J} \sum_{t_r \in T} (x_{i_m j t_r} \, d_{i_m j}^{P}) \\ \min f_2(i_m, j, t_r) = \min(\frac{\min G_y + \min G_z}{2}) \times x_{i_m j t_r} \\ \min f_3(i_m, j, t_r) = \min \sum_{i_m \in I} \sum_{j \in J} \sum_{t_r \in T} (x_{i_m j t_r} \, d_{i_m j}^{O}) \end{cases} \quad (8)$$

The constraint conditions are as follows:

$$\sum_{j \in J} \sum_{t_r \in T_r} x_{i_m j t_r} = 1 \quad \forall\, i_m \in I \quad (9)$$

$$\sum_{j \in J} \sum_{t_r \in T_r} x_{i_m j t_r} \leq 1 \quad \forall\, j \in J \quad (10)$$

$$x_{i_m j t_r} \in \{0, 1\} \quad \forall i_m \in I, j \in J, t_r \in T_r \quad (11)$$

The constraint condition (10) indicates that a cargo can only be allocated to one location, and the constraint condition (12) indicates that a location can only store one cargo.

3.3. NSGA-II

In multi-objective programming, the objective functions are mutually constrained and exclusive. It is difficult to find a single optimal solution for this kind of problem, but a series of pareto frontier solutions can be found. Traditional methods for solving multi-objective problems include weighting method, constraint method, goal programming method, etc.; Multi-objective solving methods based on genetic algorithm include VEGA, MOGA, NPGA, NSGA, NSGA-II. The non-dominated sorting genetic algorithm based on the elite strategy proposed by Deb [19] et al. introduces fast non-dominated sorting methods, elite retention strategies and the use of crowding degree and crowding degree comparison operators to ensure population diversity and improve algorithm stability, and reduce the computational complexity. Therefore, this paper uses this algorithm to optimize the multi-objective problem of fresh food cold storage space allocation.

The steps of solving the location allocation optimization model based on NSGA-II algorithm are as follows:

Step 1: input the current inventory status information and the current goods in / out information

Step 2: Set the population size “pop”, the number of iterations “gen”, generate the initial population P_t and constrain the individual to avoid the generation of illegal individuals, and calculate the individual objective function value

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Step 3: Each individual calculates the number n_i that dominates individual i in the population and the set of solution individuals S_i dominated by individual i, using fast non-dominated sorting algorithm to get individual virtual fitness r_{rank}, individuals on the same r_{rank} calculate congestion degree operator.

Step5: The parent and offspring form an intermediate population R_t to perform fast non-dominated sorting and congestion operator calculation again, Based on elite strategy selection, the new generation population P_{t+1}

4. APPLICATIONS

A three-dimensional warehouse has 8 rows, each with 10 rows and 4 floors, with a total of 320 cargo spaces. The size of the cargo space is 900mm×900mm×2060mm. The average speed of the forklift in the horizontal direction is 2.5m/s, and the average speed in the vertical direction is 0.45m/ s. The parameters of the goods are shown in the following table. The first line indicates that a certain product 1 needs to be stored in 10 pallets, and the total amount of goods on each pallet is 65kg, the turnover rate level is 7, and the freshness level is 7.

Table 6. Goods warehousing parameter table

Goods items	Quantity	Weight /kg	Turnover level	Freshness grade
1	10	65	7	7
2	12	50	4	5
3	15	68	7	7
4	5	50	7	6
5	6	30	7	4
6	7	40	2	5
7	5	25	3	6
8	12	40	1	2

Set the population size in the algorithm to 500, the number of iterations to 100, perform simulated binomial crossover with a crossover probability of 0.9, and perform polynomial mutation with a mutation probability of 0.1. Write the program and perform simulation numerical calculations, and the running results are shown in Figure 5 below:

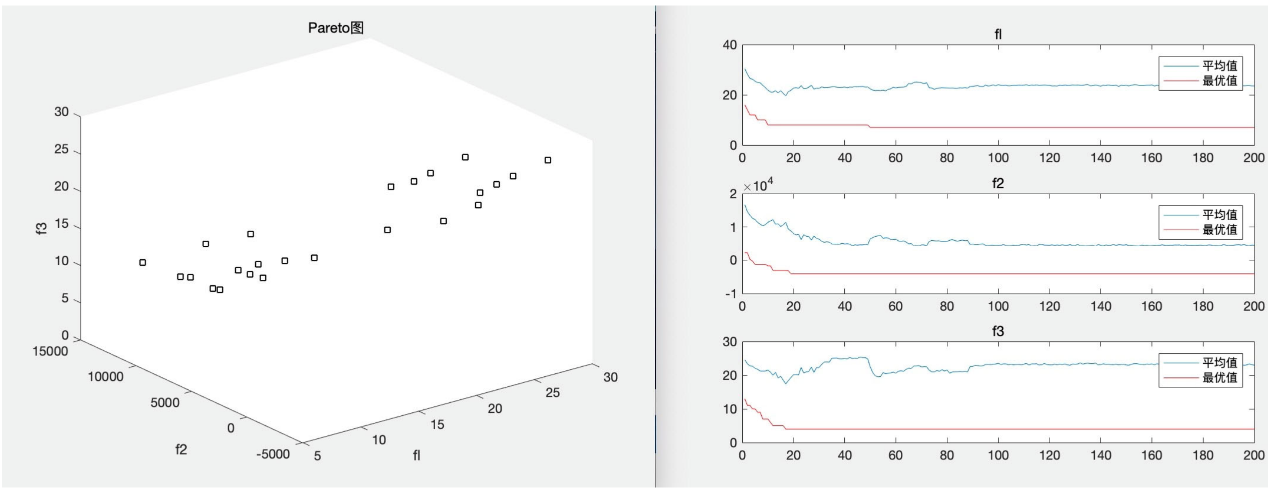

Figure 5. Pareto front solution based on NSGA-II

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Choose one from the Pareto frontier solution as the cargo distribution plan for the shift in storage. For example, for item 1, the obtained cargo location distribution plan is shown in the table:

Table 7. Location allocation scheme for item 1 to be warehoused

Incoming items 1	Row	Column	Layer
Pallrt 1	3	3	1
Pallet 2	2	2	3
Pallet 3	8	4	4
Pallet 4	6	1	1
Pallet 5	4	1	2
Pallet 6	4	1	1
Pallet 7	8	5	4
Pallet 8	2	2	1
Pallet 9	7	1	3
Pallet 10	8	8	3

5. CONCLUSION AND PROSPECT

The distribution center is an important part of the fresh produce from the place of production to the table, and its operational efficiency and service level are of vital importance. Fresh products are perishable, and unsuitable external environment will exacerbate quality loss. The actual freshness will be different due to the different operation conditions of each logistics link experienced by the fresh products from the place of production to the cold storage of the distribution center. Therefore, this article first clarifies that temperature is an important factor affecting the freshness reduction of fresh products, and proposes a method to measure the CO_2 concentration in a closed environment at different temperatures to convert the freshness decrease rate of fresh products, based on GO-FLOW method constructs a system flow chart of logistics operations and calculates the freshness rating of fresh products before they are put into storage. Using the overall freshness of the cold storage, storage efficiency, and shelf stability as indicators, a multi-objective cargo location optimization model is constructed, and the NSGA-II algorithm is used to solve the cargo location allocation plan, which makes the "first rotten" fresh products are more convenient to enter and exit the warehouse, which improves the overall freshness and operational efficiency of the fresh products stored in the distribution center.

This paper optimizes the operation of the distribution center in the later stage by tracing the logistics operation information in the early stage, so that the information on the traceable cold chain is not only a monitoring and early warning function. However, further research is needed to optimize the location of fresh products, and the influence of mutual ripening between fresh products and the seasonality of the demand for fresh products have not been considered. This article provides new ideas for the freshness rating of fresh products and the optimization of fresh food distribution centers, which is of great significance for improving the freshness of fresh products, the service level and competitiveness of distribution centers.

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