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Study on Optimization Management of Fresh Fruit Logistics Inventory

-- Taking DDMC Cold Storage as an Example

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Abstract

On the basis of field investigation, this paper applies the theory of inventory management and inventory control, takes DDMC cold storage as an example, uses ABC classification method and deterministic storage model to control the cold storage inventory, and puts forward the optimization scheme.

Keywords

ABC Classification; Inventory Control.

1. Introduction

With the overall development of national economy and the improvement of people's living standards, great changes have been made in the production and consumption of fresh fruits in China. The demand for fresh fruits is increasing and the demand for fresh fruit quality is higher and higher. The supply pattern of fresh fruits in the past has been unable to meet the national consumption level. Therefore, we must study how to improve the quality of fresh fruit supply. There are many factors affecting the quality of fresh fruit supply, among which the development of cold chain logistics is the most important restriction factor. In recent years, although the logistics industry has developed rapidly, the level of fresh fruit storage management needs to be improved. Due to the perishable and short preservation period of fresh fruits, ordinary storage, packaging, handling and other operating standards cannot meet its preservation requirements, China's annual fresh fruit loss up to tens of millions of tons, resulting in environmental pollution and resource waste is very serious, directly affecting the process of social sustainable development.

2. Inventory Control Analysis of DDMC Fresh Fruit Cold Storage

2.1. ABC Classification Analysis of Chilled Storage

To carry out effective control of fresh fruit, first, according to the type, price, volume of fresh fruit, fresh fruit to implement different management. According to the characteristics of fresh fruit, ABC classification is mainly adopted.

2.1.1. ABC Classification

Table 1. ABC classification

Category	The proportion of the goods variety's accounts for all the varieties	The proportion of the funds occupied by the inventory of the funds
A	5%—10%	70%—80%
B	15%—20%	20%—25%
C	70%—80%	5%—10%

1) Collect data;

2) Process the data;

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3) Make ABC analysis table of fresh fruit in chilled storage;

4) Determine the classification level of fresh fruits according to the content of ABC analysis table of fresh fruits in the cold storage.

2.1.2. Application of ABC Classification in Inventory Control

Class A Fresh fruit:

1) Detailed number of each piece of fresh fruit.

2) The prediction of the demand for fresh fruit in the market should be as accurate as possible.

3) Under the condition of not affecting the normal operation of the refrigerated storage, try to reduce the order quantity.

4) Coordinate with fruit growers to maximize the stability of chilled storage.

5) Cooperate with fruit growers to reduce the time needed to prepare fresh fruit.

6) Order regularly and monitor the inventory at any time.

7) Take inventory at any time, so that the fresh fruit account, goods have been convenient for temporary decision.

8) Precise delivery time and delivery time.

9) The fruit shall be placed in the storage area which is relatively advanced from the delivery area.

10) Fine packaging of fruits.

11) The ordering operation can only be carried out after the approval of the chilled storage manager.

Class B fresh fruit:

1) Quantitative order is applicable.

2) Take stock of fresh fruit when appropriate.

3) Fresh fruit procurement can be maintained in general.

4) The content of the ordering operation can be carried out only after the approval of the chilled storage manager.

Class C Fresh fruit:

1) Adopt flexible purchasing methods.

2) Expand the purchase scale and reduce the purchase price.

3) Flexible inventory management.

4) Try to avoid the phenomenon of out of stock and appropriately expand the quantity of fresh fruit in stock.

5) The inventory time is flexible and decided according to manpower and material resources.

6) The ordering operation can be carried out after the approval of the chilled storage base experience.

2.2. Deterministic Storage Model Construction

2.2.1. The Meaning of Variable Symbols

1) Order quantity (Q), that is, the quantity of one-time purchase of fresh fruits from fresh fruit suppliers in order to expand the stock of certain fresh fruits according to the actual situation of the warehouse.

2) Order point (s), that is, when the fresh fruit stock drops to this point, it should be prepared for purchase immediately. It is closely related to the stock and advance ordering time, when the

purchase of fruit warehousing before and after, the quantity of fresh fruit inventory should meet the established service standards, should not be out of file or burst.

3) Safety inventory (SS), in order to meet the lead time demand. Because there are many uncertain factors affecting the fresh fruit inventory, such as the time of ordering in advance and the demand are uncertain, the range of change may be very large. In order to maximize profits and prevent stock shortages, buffer inventory must be designed.

4) Maximum stock (S), the upper limit of the quantity of fresh fruit in stock according to the actual situation of the warehouse.

5) Minimum stock (L), the minimum value of the quantity of fresh fruit in stock according to the actual situation of the warehouse and the market, in order to avoid the situation of out of stock.

6) Average storage capacity (Q"), to ensure the average storage capacity of fresh fruits in the chilled storage under the normal operation of the chilled storage. For example, if there is an order point S, the calculation method of average inventory is: Q"= (1/2) + s, where Q= order quantity.

7) Order interval (T) refers to the length of time between two purchases of fresh fruits. That is, every certain time T, it is necessary to purchase.

8) Bookkeeping interval (R), refers to the length of time between two bookkeeping. That is, every certain time R, the book data, and bookkeeping, to ensure the consistency of accounts.

2.2.2. Fresh Fruit Economic Order Quantity Model (EOQ)

The quantitative ordering system refers to the calculation of order point S and order quantity Q by formula according to the actual situation of the chilled storage. In this case, the order quantity Q is fixed, while the order period T is not fixed. When inventory drops to order point S, the order strategy should be activated immediately. The quantity of fresh fruit purchased by fresh fruit cold storage directly affects the storage capacity and inventory cost of fresh fruit cold storage. Therefore, in order to minimize the inventory cost, fresh fruit enterprises must design a reasonable order quantity. Economical bulk order. the purchase model is specially constructed for this purpose. It calculates the optimal order quantity according to the purchase cost and storage cost, to minimize the total cost. The calculation method is:

$$Q^*=\sqrt{\frac{2AC2}{C1}}$$

A-----Annual demand; C2-----Purchase cost per purchase;

C1-----Storage cost per item per time (year);

C1=K*P;

K----Storage fee, 1 yuan per unit time (year) of the goods storage cost;

P-----Item price

2.2.3. No Out-of-stock Storage Model is Allowed for Fresh Fruit Inventory

It is assumed that the fresh fruit supplier supplies R pieces of fresh fruit supplied within T time into N batches, each batch of supply is fixed as Q pieces, and so on, until the supply of R pieces of products is completed. There are:

$$n=\frac{R}{q},\quad Ts=\frac{T}{n}=\frac{T*q}{R}$$

Where Ts refers to the period from the beginning of fresh fruit supply to the end of fresh fruit supply, During the period of Ts, the average storage level of chilled storage is $\frac{q}{2}$.C1 represents the storage cost per unit time (year) of a unit of goods, C3 represents the establishment cost of producing each batch of fresh fruits, so the storage cost in ts is: $\frac{q}{2}$*ts*C1.

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The costs incurred in each cycle ts are storage charges plus set-up charges:

$$CTs=\frac{q}{2}*ts*C1+C3$$

So, the total expected cost in time T is:

$$CT=(\frac{q}{2}*ts*C1+C3)*n=\frac{R}{q}*(\frac{q}{2}*\frac{Tq}{R}*C1+C3)=\frac{1}{2}qTC1+\frac{RC3}{q}$$

Take the derivative of CT with respect to q and set it equal to 0;

$$\frac{dCT}{dq}=\frac{1}{2}-TC1-\frac{RC3}{q2}=0;$$

$$\text{Get: } q0=\sqrt{\frac{2RC3}{q3}}$$

$$\text{Because:}\frac{d2CT}{dq2}=\frac{2RC3}{q3}>0$$

Therefore, q= q0 is the minimum value point of the total expected cost, marked as: CT0. When q= q0, ts is represented by ts0:

$$Ts0=\frac{T}{R}q0=\sqrt{\frac{2TC3}{RC1}};$$

Minimum expected total cost:

$$CT0=\frac{1}{2}Tq0C1+\frac{RC3}{q0}=\sqrt{2RTC1C3}$$

In the formula, ts0 represents the corresponding cycle period, and CT0 represents the minimum expected total cost per period.

2.2.4. Fresh Fruit Inventory Allows Out of Stock Storage Model

Set S as the storage level at the beginning of ts in each cycle, t1 as the stock time, t2 as the stock out time, (q-S) as the stock out quantity, and C2 as the stock out loss cost of fresh fruit per unit time. In t1, the average storage level is $\frac{S}{2}$, and the average storage cost is $\frac{1}{2}$t1 C1; In t2, the average stock shortage is (q-S), and the average stock shortage loss is $\frac{1}{2}$(q-S) t2 C2. Therefore, when the total expected cost within time T is:

$$CT=[\frac{1}{2}St1C1+\frac{1}{2}(q-S)\ t2C2+C3]*n$$

Because $t1=\frac{S}{q}ts$, $t2=\frac{(q-S)}{q}ts$;

$$CT=\frac{1}{2q}[\frac{S2}{2q}tsC1+\frac{(q-S)2}{2q}tsC2+C3]\frac{R}{q}$$

Because $Ts=\frac{T}{n}=\frac{Tq}{R}$;

$$CT=\frac{1}{2q}[S2TC1+(q-S)2TC2+2RC3]$$

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Take the function CT to get the minimum value, take the partial derivative:

$$\frac{\partial CT}{\partial S}=\frac{1}{q}\,[STC1\text{-}(q\text{-}S)TC2]$$

$$\frac{\partial CT}{\partial q}=-\frac{1}{2q2}\,\{S2TC1\text{-}\,[2q(q\text{-}S)\text{-}(q\text{-}S)2]TC2+2RC3\}$$

The above two equations are equal to 0 respectively, then:

$$S=\frac{c2}{c1+c2}*q;\ q2C2\text{-}(C1+C2)\ S2=\frac{2RC3}{T}$$

By solving the above two equations jointly, we can get:

$$q0=\sqrt{\frac{2RC3(C1+C2)}{TC1C2}}=\sqrt{\frac{2RC3}{TC1}}\sqrt{\frac{(C1+C2)}{C2}};$$

$$S0=\sqrt{\frac{2RC3C2}{TC1(C1+C2)}}=\sqrt{\frac{2RC3}{TC1}}\sqrt{\frac{C2}{C1+C2}}$$

Because: $\frac{\partial 2CT}{\partial q2}$>0; so, when q=q0, S=S0, CT reaches the minimum value. If we substitute q0, we have:

$$ts0=\frac{Tq0}{R}=\sqrt{\frac{2RC0(C1+C2)}{RC1C2}}=\sqrt{\frac{2TC3}{RC1}}\sqrt{\frac{(C1+C2)}{C2}};$$

Thus, the expected total cost is:

$$CT0=\frac{S02TC1}{2q0}+\frac{(q0-S0)TC2}{2q0}+\frac{2RC3}{2q0}=\sqrt{2RTC1C3}\sqrt{\frac{C2}{C1+C2}}$$

3. Optimization and Application of Fresh Fruit Inventory Management -- Taking DDMC Cold Storage as an Example

The annual demand, ordering cost, storage cost and sales unit price of all kinds of fresh fruits in this refrigerated warehouse have been collected through several in-depth investigations and studies, as shown in Table 2.

Table 2. Data information of fresh fruit

Designation	Annual demand (box)	Ordering cost (RMB Yuan)	Storage cost (yuan)	Advance Period (days)	Unit price (Yuan / box)
Apple	1508	80	55	7	650
Pear	2174	80	55	7	900
Banana	2988	80	55	7	450
Renegade	58455	80	55	7	790
Kiwi fruit	3526	80	55	7	1650
Orange	3406	80	55	7	1150
Mango	3109	80	55	7	2650
Strawberry	69006	80	55	7	260
Avocado	1983	80	55	7	1110
Cherry	99066	80	55	7	490

ABC classification was performed on this batch of fresh fruits. The classification results are shown in Table 3.

Table 3. ABC classification of this batch of fresh fruits

Product serial number	Designation	Quantity (parts)	Unit price (Yuan / box)	Occupancy Funds (RMB Yuan)	Percentage of capital occupied: %	Accumulated percentage of capital occupancy: %	Accumulated percentage of product items: %	Classification results
1	Apple	213	650	138450	2.1	2.1	2.3	C
2	Pear	307	900	276300	4.2	6.3	5.8	C
3	Banana	422	450	189900	2.9	9.2	10	C
4	Renegade	1651	790	1304290	19.7	28.9	28.7	A
5	Kiwi fruit	498	1650	821700	12.4	41.3	34.2	B
6	Orange	481	1150	553150	8.3	49.6	39.5	C
7	Mango	439	2650	1163350	17.5	67.1	44.4	B
8	Strawberry	1949	260	506740	7.6	74.7	65.9	A
9	Avocado	280	1110	310800	4.7	79.4	68	C
10	Cherry	2798	490	1371020	20.7	100	100	A

It can be seen from the results in Table 3 that fresh fruits such as blueberries, strawberries and cherries should be managed in Category A; To kiwi fruit, mango and other fresh fruit B management; Category C management for apples, pears, bananas, oranges, and avocados.

3.1. Optimization of Economic Order Batch Control for Fresh Fruit

The enterprise's annual demand for Apple A is 1508 pieces, the ordering cost S is 80 yuan/time, the storage cost C1 is 55 yuan/year, the lead time T is 7 days, and the unit price C2 is 650 yuan, then the economic order quantity of Apple is:

$$QP=\sqrt{\frac{2AC2}{C1}}=\sqrt{\frac{2*1508*650}{55}}\approx 189 \text{ piece}$$

The enterprise's annual demand for pears D is 2174 pieces, the ordering cost S is 80 yuan/time, the storage cost H is 55 yuan/year, the lead time T is 7 days, and the unit price C is 900 yuan, then the economic order quantity of apples is:

$$QP=\sqrt{\frac{2AC2}{C1}}=\sqrt{\frac{2*2174*900}{55}}\approx 267 \text{ piece}$$

The enterprise's annual demand for bananas D is 2988 pieces, the ordering cost S is 80 yuan/time, the storage cost H is 55 yuan/year, the lead time T is 7 days, and the unit price C is 450 yuan, then the economic order quantity of apples is:

$$QP=\sqrt{\frac{2AC2}{C1}}=\sqrt{\frac{2*2988*450}{55}}\approx 221 \text{ piece}$$

And so on. The results are shown in Table 4.

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Table 4. Economic ordering volume of fresh fruit chilled storage

Designation	Annual demand (box)	Ordering cost (RMB Yuan)	Storage cost (yuan)	Advance Period (days)	Unit price (Yuan / box)	Economy Order Volume (Parts)
Apple	1508	80	55	7	650	189
Pear	2174	80	55	7	900	267
Banana	2988	80	55	7	450	221
Renegade	58455	80	55	7	790	1295
Kiwi fruit	3526	80	55	7	1650	495
Orange	3406	80	55	7	1150	377
Mango	3109	80	55	7	2650	547
Strawberry	69006	80	55	7	260	807
Avocado	1983	80	55	7	1110	282
Cherry	99066	80	55	7	490	1382

3.2. Fresh Fruit Inventory does not Allow Out of Stock Control Optimization

The enterprise's annual demand for apples R is 1508 pieces, the storage cost C1 is 4.6 yuan/month, and the establishment cost of each batch of fresh fruits ordered is 3500 yuan, so T is known to be 12 (month). R=1508 (piece), C1=4.6 (YUAN/piece * month), C3=3500 (Yuan/lot), the corresponding order cycle time of Apple is:

$$ts0=\frac{Tq0}{R}=\sqrt{\frac{2TC3}{RC1}}=1.4 \text{ weeks}$$

Then the total expected cost of Apple inventory per period is:

$$CT0=\frac{1}{2}Tq0C1+\frac{RC3}{q0}=\sqrt{2RTC1C3}=24139 \text{ yuan}$$

And so on. The results are shown in Table 5.

Table 5. Cycle time and total expected cost of fresh fruit orders not allowed out of stock

Designation	Annual demand (box)	Time (month)	Storage cost (Yuan)	Establishment cost (Yuan)	Economic Order cycle Period (weeks)	Total expected cost per period (RMB Yuan)
Apple	1508	12	4.6	3500	1.4	24139
Pear	2174	12	4.6	3500	2.9	20494
Banana	2988	12	4.6	3500	2.5	24026
Kiwi fruit	3526	12	4.6	3500	2.3	26100
Orange	3406	12	4.6	3500	2.3	25652
Mango	3109	12	4.6	3500	2.4	24508
Avocado	1983	12	4.6	3500	3	19573

3.3. Fresh Fruit Stock Allows Out of Stock Control Optimization

The annual demand R of the enterprise for blueberries is 58455 pieces, and the storage cost C1 is 4.6 yuan/month. When the stock is out of stock, each piece causes a loss of 0.8 yuan/month, and the subscription fee is 80 yuan/month. Then, it is known that T=12 (months), R=58455 (pieces), C1=4.6 (yuan/piece * month), C2=0.8 (yuan). C3=80 (YUAN/batch), the corresponding ordering cycle time of blueberries is:

$$ts0=\frac{Tq0}{R}=\sqrt{\frac{2RC0(C1+C2)}{RC1C2}}=\sqrt{\frac{2TC3}{RC1}}\sqrt{\frac{(1+C2}{C2}}=0.22\text{ months}$$

So, the total expected cost of blueberry inventory per period is:

$$CT0=\frac{S02TC1}{2q0}+\frac{(q0-S0)TC2}{2q0}+\frac{2RC3}{2q0}=\sqrt{2RTC1C3}\sqrt{\frac{C2}{C1+C2}}=8746\text{ yuan}$$

And so on. The results are shown in Table 6.

Table 6. Allowed cycle time and total expected cost of Out-of-stock fresh fruit ordering

Designation	Annual demand (box)	Ordering cost (RMB Yuan)	Storage cost (yuan)	Loss expense (RMB Yuan)	Order cycle period (month)	Total expected cost per period (RMB Yuan)
Renegade	58455	80	4.6	0.8	0.22	8746
Strawberry	69006	80	4.6	0.8	0.2	9502
Cherry	99066	80	4.6	0.8	0.17	11385

4. Conclusion

The inventory cost can be obviously reduced by using scientific storage method to control the refrigerated warehouse. This paper constructs fresh fruit inventory ABC classification model and fresh fruit inventory determinate storage model, such as EOQ model, not allowed to be out of stock model and allowed to be out of stock model, and uses the relevant models to carry out empirical analysis, to achieve the fresh fruit storage enterprise order cost and storage cost of the sum of the minimum, to reduce the fresh fruit inventory cost.

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