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Research on Vegetable Sales and Inventory Optimization Based on Fuzzy Comprehensive Evaluation

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Abstract: *The current sales of fresh vegetables face challenges due to seasonality, perishability, and price fluctuations, necessitating optimized inventory management through precise replenishment and pricing strategies. This study begins with dataset preprocessing to calculate annual sales across individual products and categories, examining correlations between various vegetable categories and personal products. By analyzing average sales volume and revenue per product, this study assess six key factors—unit price, sales volume, wholesale price, loss rate, and daily replenishment—to identify the optimal category choice. Specifically, for July 1st, our analysis recommends prioritizing the purchase of eggplants, moderately purchasing cauliflower, leafy vegetables, chili peppers, and mushrooms, while minimizing root and stem vegetable purchases. Using an evaluation model, this study determined that the average loss rate is the most influential factor, followed by unit price and wholesale price. In contrast, the average profit margin is less critical. This research offers theoretical guidance for automated pricing and replenishment strategies in vegetable sales.*

Keywords: *Fuzzy Comprehensive Evaluation, Value Loss, Vegetable Sales, Inventory Optimization*

1. Introduction

This study provides theoretical guidance for automatic pricing and replenishment decisions of vegetable products. Supermarkets and stores face dual challenges in inventory management and pricing strategies when selling vegetables. Due to the short shelf life of vegetables, how to reduce losses, and increase sales volume and profits through reasonable replenishment and pricing strategies has become a key research topic[1]. Meanwhile, consumers' demand for different types of vegetables is influenced by various factors, including seasonal changes, price fluctuations, and consumer preferences. Therefore, accurately predicting and meeting market demand is of great significance for optimizing the supply chain and enhancing the competitiveness of enterprises[2].

This study is based on multiple-factor analysis and fuzzy comprehensive evaluation methods. Firstly, the sales distribution of various vegetable categories is obtained from sales data. Then, the total sales of each category during a given period are calculated ranked, and compared to understand which categories are popular in the market and which categories may have lower demand[3-5]. After solving the objective function, the fuzzy comprehensive evaluation mathematical model established above is solved. By using a fuzzy comprehensive evaluation model, the weight data of six major vegetable types are obtained. Based on the weight data, the selection order of the six major vegetable types is arranged, and the types for large-scale procurement, moderate procurement, and small-scale procurement are given. Each of the six major vegetable categories contains several types of vegetables. A fuzzy comprehensive evaluation model is applied to different types of vegetables to eliminate the influence of category factors and obtain a weight map. The selection method is the same, thus obtaining a refined and accurate category procurement list and pricing strategy.

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2. Data Sources and Preliminary Analysis

2.1 Preliminary visualization

The data for this study is sourced from https://cumcm.cnki.net/cumcm/. The dataset has a large amount of data, so preprocessing of the data is necessary. Firstly, for the detailed sales flow data in the dataset, classify the sales data by category based on the item code. Then, the sales flow details data in the dataset were screened, as returned and discounted products represent adjustments and reductions to the original sales data and do not reflect actual sales volume. Therefore, they were not considered in the sales volume statistics to ensure the accuracy and reliability of the data. Therefore, this article selected vegetable data with normal sales as the sales type and excluded vegetable data with returns and discounts. The sales flow details of stores and supermarkets are provided in the dataset. The data refers to the purchase data of stores and supermarkets at different times of the day.

After analyzing the data, summarize the monthly sales volume of individual products. Create a chart based on the summarized data. The changes in vegetable sales over time are represented by a line chart, while the data on vegetables and unit prices are represented by a bar chart. The following charts, from left to right, represent cowhead rapeseed, Sichuan red spring toon, local Chinese cabbage, and cabbage moss. As shown in the figure, the sales of oilseed rape will increase from October in winter to January next year. Sichuan Hongchun Chunchun has the highest sales volume from March to April. The sales of cabbage moss will significantly increase from January to March. In addition, the following four images show the relationship between sales volume and unit price. Among them, the lower the money, the higher the sales. There is a correlation between sales volume and unit price. The following figures 1-5 shows some data images.

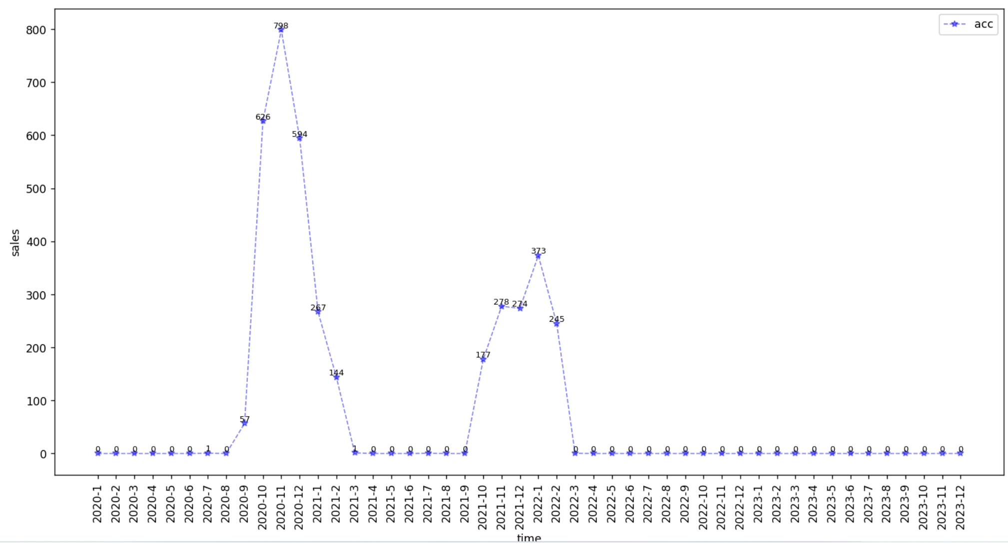

Figure 1.Sales Volume of Beef Head Rapeseed

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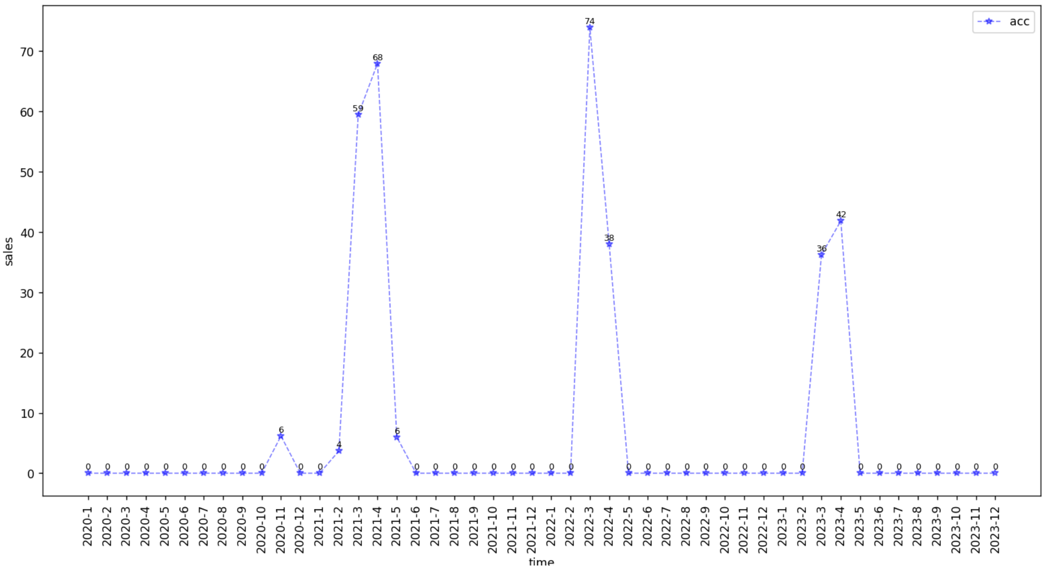

Figure 2. Sales Volume of Sichuan Red Spring Toon

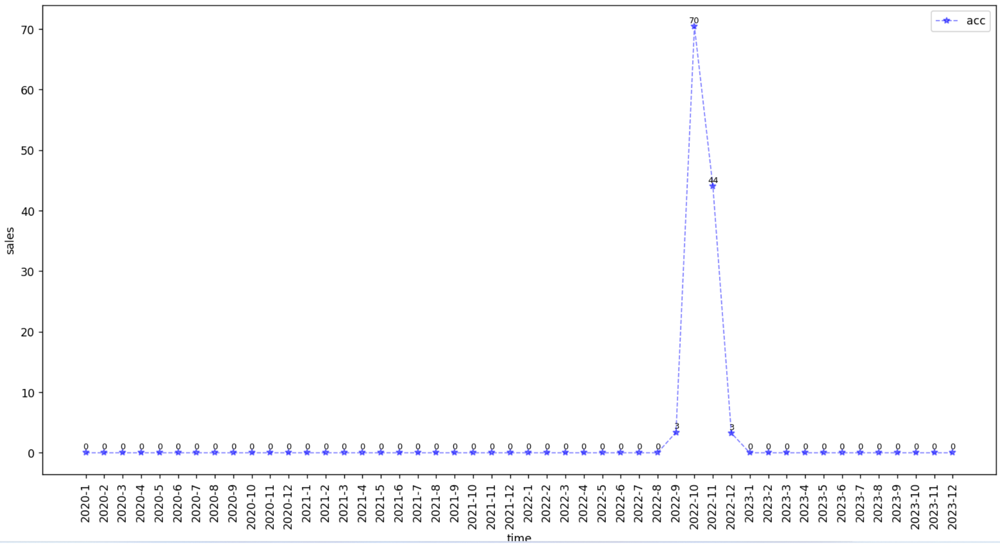

Figure 3. Sales Volume of Cabbage Moss

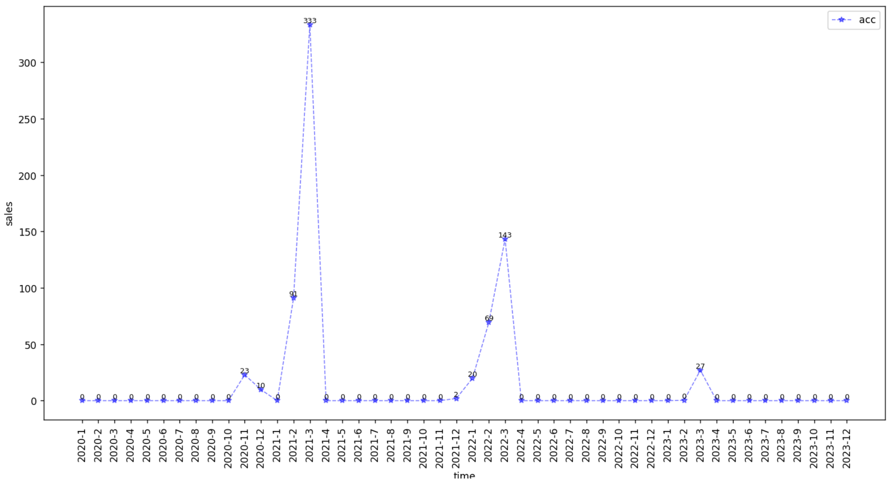

Figure 4.Sales volume of local Chinese cabbage

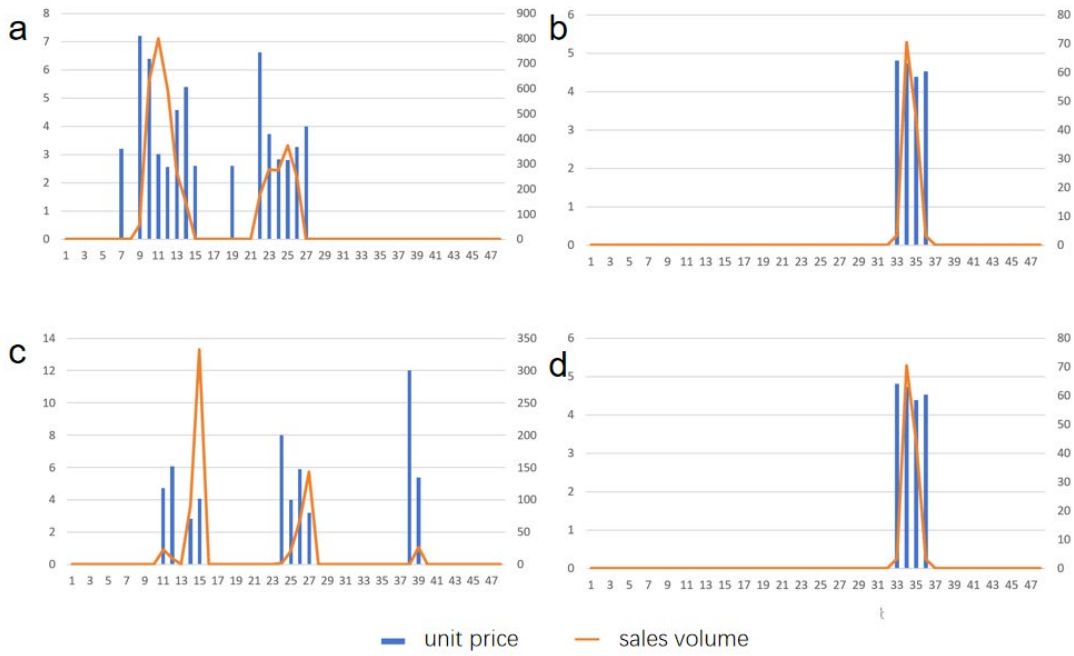

Figure 5. Visualization of sales and pricing of different types of vegetables. (a) Cattle head rapeseed (b) Sichuan red spring toon (c) Local small hairy cabbage (d) Cabbage moss

2.2 Correlation analysis

After summarizing the sales volume of different individual vegetables in the dataset, the sales volume of different categories of vegetables is then summarized. Determine the average sales volume of this vegetable category based on this data. As shown in Table 1.

Table 1: Total Vegetable Sales

Classification name	Average sales volume of similar products
Flowers and leaves	2002.262
florescent vegetables	8353.290
Aquatic rhizomes	2135.860
Eggplant type	2243.178
Chili peppers	2035.303
edible fungi	1056.760

This article uses heat maps to analyze the distribution patterns and interrelationships of sales volume for various vegetable categories and individual products. A heatmap can visually display the correlation between different categories or items, using colored blocks to indicate the strength of the correlation. Brighter colors indicate a higher correlation, while darker colors indicate a lower correlation. The scale on the right side of the heatmap displays the color depth corresponding to different correlation coefficients. From the heat maps of different vegetable categories in Figure 6, it can be concluded that the correlations between purple eggplant and green eggplant, round eggplant and green eggplant, and round eggplant and purple eggplant are all 100%. This means that there is a complete positive correlation between these vegetable categories, and their sales volume changes are highly consistent. This highly correlated situation indicates that there is a certain substitution relationship or similar market demand between these vegetable categories. There is a strong multicollinearity between every two individual products in the three combinations of purple eggplant and long eggplant, purple eggplant and long eggplant, and purple eggplant and purple eggplant. There is a negative correlation between every two individual products in the combination of round eggplant and green eggplant, as well as round eggplant and purple eggplant. There is also a negative correlation between round eggplant and round eggplant, indicating that there is a certain reverse relationship in the quantity changes between round eggplant and the three individual eggplants mentioned above.

From the heat maps of different vegetable items in Figure 7, it can be concluded that the correlation between aquatic rhizomes and edible vegetables is 98%, the correlation between flowering leaves and cauliflower is 96%, and the correlation between aquatic rhizomes and cauliflower is 93%. This indicates

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that there is strong multicollinearity and correlation between aquatic rhizomes and edible vegetables, flowering leaves and cauliflower, and aquatic rhizomes and cauliflower, and there may be close substitution relationships or similar market demands between them, which can be considered in replenishment and pricing strategies to better manage inventory and meet consumer needs. The correlation between chili peppers and eggplants is 0.4%, indicating a moderate positive correlation between chili peppers and eggplants, but the correlation is not strong. This suggests that they may have similar market demand in certain specific situations, but are not always completely replaced. In replenishment and pricing decisions, supermarkets can consider this correlation but also pay attention to the possible differences between chili and eggplant products to better meet the diverse needs of consumers.

Figure 6 Heat map of different vegetable categories

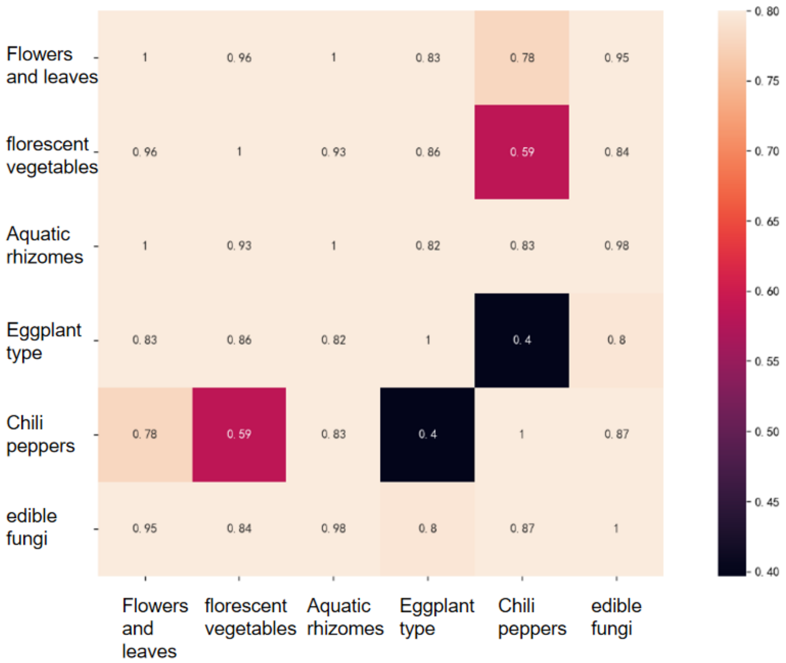

Figure 7 Heat map of different individual vegetables

3. Saleable Product Analysis and Optimization Strategy

Sort out the available varieties from June 24th to June 30th, 2023 in the dataset. The following table 2 is partially shown.

Table 2 List of sellable varieties at the end of June

Sale date	Item code	Product Name
2023-06-24	102900011032022	Small wrinkled skin (portion)
2023-06-24	102900005115786	smilacina atropurpurea
2023-06-25	102900011030059	Yunnan lettuce (portions)
2023-06-25	102900005115786	smilacina atropurpurea
2023-06-26	102900011008164	milk cabbage
2023-06-26	102900011016701	Wuhu Green Pepper (1)
	....	
2023-06-30	102900011016701	Wuhu Green Pepper (1)
2023-06-30	102900011022764	Long line eggplant

Table 3 Weight Calculation Results

	Classification name	Average sales volume (kg)	Average selling price (yuan/kg)	Wholesale price per kilogram (yuan)	Average loss rate (%)	Average profit margin (%)	Average daily replenishment quantity
Membership degree	0.126	0.024	0.273	0.183	0.346	0.022	0.026
Normalization of membership degree[weight]	0.126	0.024	0.273	0.183	0.346	0.022	0.026

From the above table 3, it can be seen that fuzzy comprehensive evaluation is conducted for 6 indicators and 7 comment sets, and the M (.,+) operator is used for research.

Firstly, establish an evaluation index weight vector matrix A, and construct a 6x7 weight judgment matrix R. Finally, analyze the weight values of seven comment sets, which are: 0.126, 0.024, 0.273, 0.183, 0.346, 0.022, 0.026.

From Table 3 above, it can be seen that the weight value of the average loss rate (%) in the 7 comment sets is the highest (0.346). Combined with the maximum membership degree rule, the final comprehensive evaluation result is "average loss rate(%)".

Using SPSSAU to analyze data, the importance of each factor is (from high to low): average loss rate>average selling price>average wholesale price>classification name>average daily replenishment volume>average sales volume, and average profit margin. From this, it can be concluded that the replenishment quantity and pricing strategy on July 1st prioritize the situation of average loss rate, and for varieties with excessive loss rate, choose the appropriate time based on the size of the average sales unit price. To maximize profits, it is recommended to purchase more eggplants and less aquatic roots and stems, and to purchase appropriate amounts of cauliflower, flower leaves, chili peppers, and edible fungi.

4. Conclusions

This study presents a framework for optimizing fresh vegetable inventory and pricing strategies in supply chain management by analyzing sales data, loss rates, and price fluctuations. Looking forward, this approach aims to provide robust data support for more scientific replenishment and pricing decisions amid seasonal fluctuations, high loss rates, and price instability. As data analysis tools advance, this study envision integrating additional data sources—such as weather patterns, holidays, and consumer behavior—to improve predictive accuracy. Testing and refining this model across diverse, practical settings will enable adaptation to varying regional and business scales. Through ongoing research and practice, this approach promises to enhance efficiency and intelligence in vegetable supply chain management, boosting both profitability and brand competitiveness in a dynamic market. In the future, research directions will focus on expanding the scope of data integration to include real-time tracking

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and IoT data for better inventory management. This will involve exploring machine learning algorithms that can process streaming data to predict demand and optimize stock levels in real-time. Additionally, there is a need to investigate the impact of sustainable practices on supply chain efficiency and how they can be incorporated into the framework to support environmental sustainability goals.

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