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Analysis and Optimization for the Collocation of Canteen Dishes

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ABSTRACT. *In recent years, with the country's emphasis on education, the number of students in school has been increasing, and the burden on school cafeterias has also increased. This paper started with a statistical survey of canteen data in a school in Shanghai. Physical materials and vegetable varieties were considered in linear programming model to analyze collocation of canteen dishes. By comparing the relationship of various factors, a mathematical model of its configuration system was established to optimize and achieve the best operating status of the canteen. This work has very important economic value and practical significance.*

KEYWORDS: *Dish allocation, linear programming, benefits*

1. Introduction

With the improvement of living standards, people's requirements for food are getting higher and higher. Not only should they be full, they can also eat well, healthy and nutritious [1-2]. The supply of meals in the canteens, especially the optimization of the allocation of dishes, is of great significance to improve the quality of their services. Based on the linear programming optimization model, this paper studies the dish allocation problem in the canteen. We learned about many aspects of the dining hall dining issues, such as queuing problems, cost problems, and teacher and student satisfaction. The canteen window was used as an example to build canteen recipe optimization model. We asked the chefs and managers of the cafeteria, and from the general grasp of the ingredients, prices, and consumption of the meals, through interviews, we learned that the current model of the cafeteria's recipe model is still determined by the chef based on his experience. This method often produces an overflow phenomenon when purchasing ingredients, and often leaves the remaining ingredients for use the next day for processing. Therefore, we found that it is necessary to establish a mathematical model to calculate the number of recipes. In order to establish an integer programming model, the aim is to provide a feasible recipe optimization solution for the canteen. Combined with the main nutritional elements contained in the ingredients, the research problem can be transformed from qualitative to quantitative.

Linear programming is a very common model, and many scholars have conducted in-depth exploration and research. Recently, from the perspective of the satisfaction of the matching subjects, the optimization model of solving the matching results was established with the goal of maximizing the total satisfaction of the matching portfolio [3]. This paper surveys the canteen to obtain feedback data on the needs of dining staff and students. Then a linear programming benefit maximization model was established. Lingo programming calculation was used to determine the optimal solution for the dish allocation. Our work is to achieve a win-win situation between the cafeteria and teachers and students.

2. Models

Linear programming is an important branch of early research, rapid development, wide application, and mature methods in operations research [4-5]. It is a mathematical method to assist people in scientific management. Mathematical theory and methods for studying the extreme value problem of linear objective function under linear constraints. The objective function $f(x)$ is the form of the objective pursued by design variables, so the objective function is a function of the design variables and is a scalar. In the engineering sense, the objective function is the performance standard of the system, for example, the lightest weight, the lowest cost, and the most reasonable form of a structure; the shortest production time and minimum energy consumption of a product; the optimal formula for an experiment, etc. The process of establishing the objective function is the process of finding the relationship between the design variable and the objective. The relationship between the objective function and the design variable can be represented by a curve, a surface, or a hypersurface. The most common and most intuitive form of describing linear programming problems is the standard type. The standard type includes the following parts: A linear function that needs to be maximized:

$$\Sigma c_k x_k \ (k = 1,2, ..., \mathrm{n})$$

Constraints of the following form:

$$\begin{gathered} a_{11}x_1 + a_{12}x_2 + ... + a_{1n}x_n < b_1 \\ a_{21}x_1 + a_{22}x_2 + ... + a_{2n}x_n < b_2 \\ ... \\ a_{n1}x_1 + a_{n2}x_2 + ... + a_{nn}x_n < b_n \end{gathered}$$

And non-negative variables:

$$\begin{gathered} x_1 > 0 \\ x_2 > 0 \\ \dots \\ x_n > 0 \end{gathered}$$

Other types of problems, such as minimization problems, different forms of constraint problems, and problems with negative variables, can be rewritten as the standard type of their equivalent problems.

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3. Case Analysis

When considering the whole issue, we should pay attention to the revenue of the sale. We also considered the purchase cost of the dish material, the freight, and the electricity cost of storing the material [6]. So the daily materials do not exceed the maximum inventory of the refrigerator. Besides, We took the following as an example of the price of various types of vegetables to find the best mix of dishes and seek the maximum profit.

Table 1 Unit price of ingredients

Ingredient	Green	Tomato	Potato	Burdock	Band fish	Shrimp	Shiitake mushroom	Crab
Price (¥/500g)	2	2.5	1	26	17.5	20	6	60

Table 2 Recipes of dishes

	Dish 1	Dish 2	Dish 3	Dish 4	Dish 5	Dish 6
Green (g)	0	100	0	0	0	0
Tomato (g)	0	0	0	0	50	0
Potato (g)	200	0	0	0	50	0
Burdock (g)	200	0	0	0	50	300
Band fish (g)	0	0	100	300	0	0
Shrimp (g)	0	0	100	0	0	0
Shiitake Mushroom (g)	0	0	0	0	10	100
Crab (g)	0	150	75	0	0	0
Profit (¥/per dish)	50	75	150	75	20	100

We made some assumptions about the problem. Let the storage quality be M. P is the quality of the ingredients sold. Let S be the quality of the purchased ingredients, let F_i be the unit price of the ingredients. F_k was the price of each dish, and let the freight be T. We knew that the profit is the net income minus the cost, that is, the price of the purchased ingredients and freight, and the cost of the refrigerator storage can also be said to be the storage fee. The net profit is the daily profit of the restaurant plus the profit of each dish plus the profit of the ingredients used in each dish. Finally, the result of the sum was multiplied by 6, because the restaurant is open for 6 days. The equations are

$$P = \sum_{i=1}^{6} P_i$$

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$$P_i = \sum_{j=1}^{6} P_{ij}$$

$$P_{ij} = \sum_{k(1-8)}^{6} P_{ijk}$$

P is the income obtained by the restaurant every day. P_i is the income obtained by each dish, and P_{ij} is the benefit obtained by the ingredients used in each dish.Adding these formulas and multiplying together is the result we need, which is pure income.

$$\sum_{i=1}^{6} \sum_{j=1}^{6} P_{ij} f_j$$

The last is that the formulation of the entire formula satisfies the conditions.

$$Max \sum_{i=1}^{6} \sum_{j=1}^{6} P_{ij} f_j - \sum_{k=1}^{8} S_k f_k - TS - S \sum_{i=1}^{6} (M_i - 1/2 P_i)$$

There is usually a certain distance between the material side of the restaurant and the restaurant. If we need the side to provide it, we must make an appointment in advance. After writing the formula, there are constraints on the formula.

$$m_1 \leq R$$
$$m_i = M_{i-1} + P_{i-1} + S_{i-1} = \sum_{k=0}^{i-1} Sk - \sum_{k=1}^{i-1} P_k$$
$$\sum_{i=0}^{n} S_i \leq \sum_{i=1}^{n+3} Pi \quad (n = 0-5)$$
$$S_{ik} \geq 0$$
$$P_{ijk} \geq 0$$
$$M_0, P_0, P_7, P_8 = 0$$
$$i, j = 1,2,3,4,5,6$$

Figure 1 The specific requirements of the Lingo software for all conditional constraints for calculation according to the formula of the previous column.

Through the above solution, we could know that the final solution result is shown in Table 3.

Table 3 The final solution about the mass of ingredients

Ingredient	Green	Tomato	Potato	Burdock	Band fish	Shrimp	Shiitake Mushroom	Crab
Mass (500g)	61	59	112	230	113	38	42	79

4. Conclusion

In this paper, a mathematical model of dish matching is established, and a linear programming method is used for analysis. The price of physical materials such as greens, tomatoes, potatoes, burdock, band fish, shrimp, shiitake mushrooms, and crabs were considered. Operating status, the result was the quality of the physical materials. The research in this paper has very important economic value and practical significance.

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