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The Decision-making for Feed Formula in Animal Husbandry Breeding based on the Revised Simplex Method

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Abstract: Aiming at many uncertainties in the process of large-scale animal husbandry, the need of nourishment is different according to the categories, the species, the physiological states, the production levels, and the environment. For the target low cost and high yield, this paper puts forward the feed formulation decision-making technology and method based on the improved simplex algorithm. It also introduces the application in the animal husbandry expert system.

Keywords*: *revised simplex method; animal husbandry; expert system; feed formula; decision-making

I. INTRODUCTION

In animal husbandry there are many uncertainties, the need of nourishment is different according to the categories, the species, the physiological states, the production levels, and the environment. At the same time, feeding and breeding enterprises and owners, designs feeding formulas using a variety of materials for screening in order to obtain much more economic benefits. Therefore, it is difficult to meet the computing requirements with the traditional artificial ingredients. With the development of information technology, have come computer design techniques and methods of feed formula feeding. The application of computer design is to solve a variety of feed formula feeding raw materials. To meet the nutritional needs of many indicators, modern computer technology match out the best feed formula with the lowest cost. To achieve the maximum production potential of livestock and poultry, to improve the feed conversion rates, to increase productivity, and to reduce costs, the key technical measure is to configure the perfect nutrients and balance nutritional daily ration. At present, feed formulas for feeding mainly include linear programming, goal programming, fuzzy optimization method etc. This paper describes how to apply the linear programming theory of operations research, and is aimed at the simplex method to solve the shortage problem, such as to compute efficiency, accuracy and computer storage space etc. When obtaining the optimal feed formula, the paper presents a revised simplex method to compute the optimal feed formulation.

II. MATHEMATICAL MODELING OF FEED FORMULA

The feed formula is designed that to solve an equation with a variety of raw materials, to meet the number of indicators for the nutritional needs, and with the lowest cost match out the best of the feed formula and to give the maximum production potential of livestock and poultry, improving the conversion efficiency of feed. Therefore, the feed formula can be expressed as a mathematical description of the objective function in a line shape, that is, a set of linear constrains the minimum problem.

$$MinS = c_1x_1 + c_2x_2 + \cdots + c_nx_n \tag{1}$$

$$\text{s.t.}\begin{cases} a_{11}x_1 + a_{12}x_2 + \cdots + a_{1n}x_n \ge (=,\le)b_1 \\ a_{21}x_1 + a_{22}x_2 + \cdots + a_{2n}x_n \ge (=,\le)b_2 \\ \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \\ a_{m1}x_1 + a_{m2}x_2 + \cdots + a_{mn}x_n \ge (=,\le)b_m \\ x_1, x_2, \cdots, x_n \ge 0 \end{cases} \tag{2}$$

Among them, where x_j is the decision variables, namely, the proportion of raw materials in the formula; where a_{ij} is the technical coefficient, that is, the appropriate nutrient composition of various raw materials; where b_i is the constraint value, that is, the formula should meet the nutritional indicators or weight indicators; Where b_i is the cost coefficient, that is the coefficient of each raw material prices; set m as the number of constraints, and set n as the number of variables, that is, the number of species of raw materials.

III METHOD OF FEED FORMULA BASED ON THE SIMPLEX METHOD

The simplex method is an effective method for solving linear programming problems in the optimization design, and it is used widely in solving linear programming problems. The basic idea is that to find a feasible solution in the feasible domain of linear programming first, check whether it gives optimal solutions or not. If it is an optimal solution, stop the calculation. If it is not an optimal solution, determine the optimal solution for linear programming or according to certain steps via the optimal objective function, obtain near optimal value which brings it close to another basic feasible solution. Because the number of basic feasible solution limited, always go through the finite iterations to get the basic feasible solution in the optimal linear programming, or judge the linear programming without bounded optimal solutions.

Simple linear programming can use the simplex method in tabular form. Form solution of the simplex method: a feasible solution via the basis to build the simplex tableau. Judge the

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optimal solution based on this table, and calculate the conversion from the primordial of the feasible solution to the target value which is smaller and the feasible solution conversion calculations.

Set the standard linear programming problem:

$$\max Z = CX \quad (3)$$

$$s.t\begin{cases} AX = b \\ X \geq 0. \end{cases} \quad (4)$$

The introduction of a feasible basis matrix B , without loss of generality set matrix $B = (p_1, \cdots, p_m)$, so the coefficient matrix A can be divided into blocks (B, N) . The corresponding to B 's basic variables is $X_B = (x_1, x_2, \cdots, x_m)^T$; $N = (p_{m+1}, p_{m+2}, \cdots, p_n)$, the corresponding non-basis variables is $X_N = (x_{m+1}, x_{m+2}, \cdots, x_n)^T$. Then:

$$X = \begin{bmatrix} X_B \\ X_N \end{bmatrix}$$

Correspondingly there is $C = (C_B, C_N)$, where C_B denotes the basis variable's coefficient row vector, where C_N denotes non-basis variables X_N 's coefficient row vector. The original problem changes into:

$$\operatorname{Max} Z = C_B X_B + C_N X_N \quad (5)$$

$$\text{s.t.}\begin{cases} BX_B + NX_N = b \\ X_B, X_N \geq 0. \end{cases} \quad (6)$$

Pre-multiply the matrix B^{-1} by both sides of Eq. (6), it will obtain as follows:

$$X_B = B^{-1}b - B^{-1}NX_N \quad (7)$$

Adding Eq. (7) to Eq. (5) obtains:

$$Z = C_B B^{-1} b - (C_B B^{-1} N - C_N) X_N \quad (8)$$

Set non-basis variables $X_N = 0$, obtains $X_B = B^{-1}b$, and then corresponding basis for feasible solution is that

$$X = \begin{bmatrix} X_B \\ X_N \end{bmatrix} = \begin{pmatrix} B^{-1}b \\ 0 \end{pmatrix} \quad (9)$$

Where the objective function is matrix $Z = C_B B^{-1} b$ .Due to $C_B B^{-1} B - C_B = 0$, so it also has the following equation,

$$\begin{aligned} Z &= C_B B^{-1} b - (C_B B^{-1} B - C_B) X_B - (C_B B^{-1} N - C_N) X_N \\ &= C_B B^{-1} b - (C_B B^{-1} A - C) X \end{aligned} \quad (10)$$

Denoting Eq. (3) and Eq. (4) respectively be rewritten as the following forms,

$$X_B + B^{-1} N X_N = B^{-1} b \quad (11)$$

$$Z + (C_B B^{-1} N - C_N) X = C_B B^{-1} b \quad (12)$$

Table □, which names simplex tableau with the form of the matrix corresponding to matrix B can be obtained, and it is denoted by $T(B)$.

TABLE I. SIMPLEX TABLEAU

	X_B	X_N
$B^{-1}b$	I	$B^{-1}N$
$C_B B^{-1} b$	0	$C_B B^{-1} N - C_N$

III. REVISED SIMPLEX METHOD TO SOLVE FEED FORMULA

From table Ⅰ, the key is the inverse of the current basis in the entire iterative process. That is, using the inverse model of the current basis of initial data it can be determined in the iterative process of concerned data. The initial simplex method in the iteration process, data which has nothing to deal with the iteration process affects the efficiency in using computer programming to solve it, and it takes up a lot of the memory sizes. Meanwhile, successive iterations will continue to increase in the accumulated error, affecting computational accuracy. In table Ⅰ, based on the research, revised simplex method steps are as follows:

- Step 1: First construct the initial feasible basis matrix B , under normal circumstances where matrix B is chosen as identity matrix, then that is $B^{-1} = B = I$. Work out the initial solution.
- Step 2: Calculate the simplex multiplier $Y = C_B B^{-1}$, and then calculate the checking number of non-basic variables σ_N , $\sigma_N = YN - C_N$. If $\sigma_N \geq 0$, get the optimal solution, then stop the calculation. Otherwise, turn to the next step.
- Step 3: Make $s = \min\{j \mid \sigma_j < 0, 0 \leq j \leq n\}$, to determine where x_s denotes the entering variables, and calculate the vector $B^{-1}p_s$ if $C_B B^{-1} p_s \leq 0$, then the problem is unbounded solutions, stop calculation. Otherwise, turn to the next step.
- Step 4: Calculate
  $$\theta = \min\left\{ \frac{(B^{-1}b)_i}{(B^{-1}p_s)_i} \mid (B^{-1}p_s)_i > 0 \right\} = \frac{(B^{-1}b)_r}{(B^{-1}p_s)_r}$$
  Confirm the corresponding base variables x_r , where x_r denotes the leaving variables. So get a new set of basis variables and the new basis matrix B_1 .
- Step 5: Calculate the inverse of new base matrix B_1^{-1}, and then get $B_1^{-1}b$ .Go back to Step 2.

The last round of iteration-based and the next round of iteration-based only differ between columns, so that, where $E = (e_1, \cdots, e_{r-1}, \xi, e_{r+1}, \cdots, e_m)$, e_i denotes the i position's element equals 1, and the remaining units for m-dimensional column vector is zero.

$$\xi = \begin{bmatrix} -a_{1s}/a_{rs} \\ -a_{2s}/a_{rs} \\ \cdots \quad \cdots \\ 1/a_{rs} \\ \cdots \quad \cdots \\ -a_{ms}/a_{rs} \end{bmatrix} \begin{matrix} \\ \\ \\ \leftarrow \text{line} \cdot r \\ \\ \\ \end{matrix} \quad (13)$$

When due to the initial matrix B is the unit matrix, thereby matrix B^{-1} also is the unit matrix. Thus at the beginning of the calculation, calculating the inverse matrix is no longer need.

IV. Sheep Breeding Expert System Decision-Making to Achieve Feed Formula Feeding

The following takes an example of a sheep with 40 kilograms of body weight. It introduces a way of achieving decision-making for feed formula in sheep breeding expert system.

A. Building Database

According to the regularity of sheep breeding and expert system theory, the sheep feed formulation decisions are *Feed Ingredient*, *Feed Type*, *Feeding Standards* and *Categories of Sheep* which are several types of data structures and used to establish the corresponding data model. Its feeding standard library is shown in Fig.1.

Figure 1. Feeding standards

B. The decision-making data flow of feed formula in sheep breeding of expert system

Making decisions, the users specify the type of sheep. According to the species that are chose, the type of weight list is produced for being selected by users. Until the users select raw materials, fill out the price of raw materials and submit it into the decision-making system, the system has calculated to optimal feed formula which has been returned to users. Decision-making system data flow diagram is shown in Fig. 2.

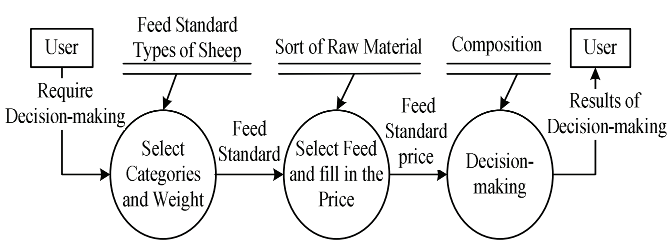

Figure 2. Data flow chart of decision-making system

C. The Structural Design of Decision-making System

According to expert system's framework, a decision-making module which achieves sheep feed formula also uses B/S 3-tier system structure (Fig. 2). Section □tier: Client tier. Use of existing popular browsers (such as Internet Explorer, Google Chrome, etc.), as a user's client, make service access to the system as a service request and output. Section □tier: middle tier, the business logic - the system functional requirements to achieve. Section □tier: Data server tier, storage, management system knowledge database, and using SQL Server 2000 to achieve the effective management of data.

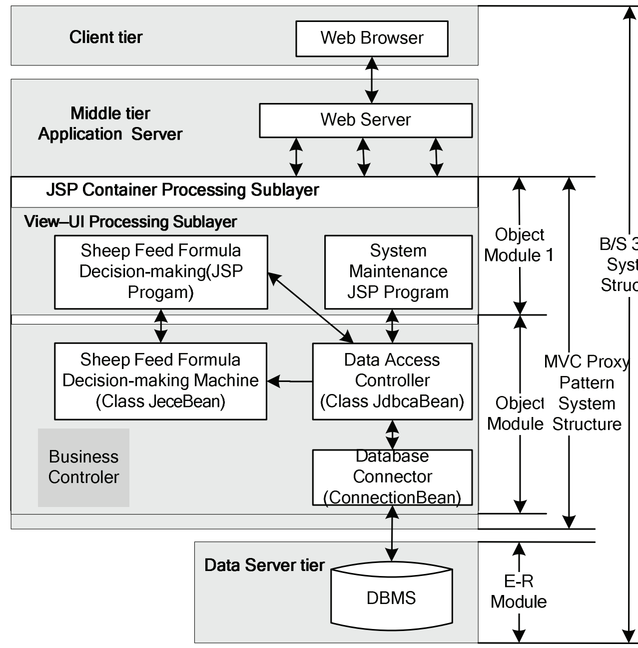

Figure 3. The structure of System implementation

D. System Implementation

System implementation shows in Fig.3 and Fig.4. Users first select the type of sheep and the weight of sheep, and then select feed in existence, fill in the market price of feed, and click the decision button. Finally the internal system utilizes the revised simplex algorithm to calculate that the results meet the requirements of the best and most economical diet formula.

Figure 4. Choosing the feeding and the prices

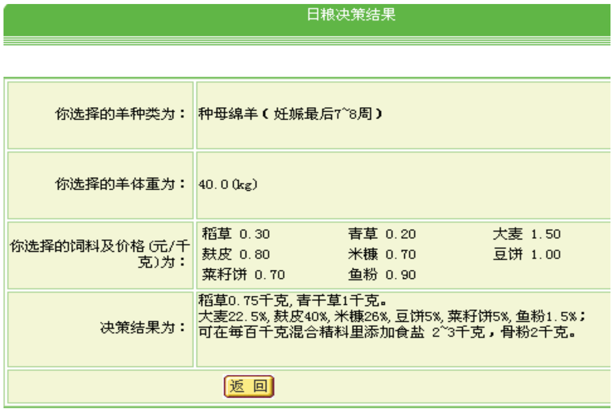

Figure 5. The results of decision-making

V. CONCLUSION

This paper mainly introduces the problem of the feed formula about the Sheep Breeding Expert System. It enlarges the issue and the revised simplex method which can be used for any optimization problem of livestock feed formula. The key to the simplex algorithm is that it transforms the actual problem into the optimization problem, which is the demand for the feed formula problem with minimum cost. If it considers the added drugs, additives and other aspects of practical constraints, then the complexity of this problem is even greater, and the state space is more complex. How to solve these problems needs further research.

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