Research on the optimization of dietary recipes based on neural network optimization algorithms

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Abstract. The paper developed an optimization model that not only focuses on protein quality but also ensures that daily food calories for both genders fall within recommended ranges to meet nutritional needs. With affordability in mind, the present paper identified the lowest-priced breakfast options. Furthermore, wethe paper constructed a daily diet optimization model that balances protein quality and economy, achieving multiple goals of nutrition, taste, and cost-effectiveness through refined algorithms. Scaling up to a one-week meal plan, the present paper designed three distinct optimization models for men and women. These models prioritize maximizing protein amino acid scores, minimizing meal costs, and a combination of both. The resulting meal plans meet nutritional needs while remaining economical, providing a comprehensive weekly meal guide. Based on the paper research, The present paper compiled dietary recommendations that emphasize the importance of amino acid intake in proteins, offer effective cost control methods, and guide individuals on finding the optimal balance between nutrition and economy. The paper aim is to promote healthier, science-based eating habits that support overall development. These recommendations not only ensure nutritional adequacy but also align with economic considerations, making them practical and sustainable for daily use.

Keywords: Neural Network, Genetic Algorithm, Annealing Method, Amino Acid Scoring Method.

1. Introduction

In contemporary society, the heightened awareness of health has made scientific and rational daily diet planning a focal point for individuals. This is particularly evident in university settings, where students often overlook balanced and nutritious diets in their pursuit of academic and career goals. Against this backdrop, this article explores the provision of nutritious and cost-effective meal choices. An optimization model, centered on protein quality, has been developed to prioritize nutritional requirements [1], ensuring that daily food calorie intake remains within recommended limits. Simultaneously, recognizing the financial constraints faced by students, the article identifies the most economical breakfast recipe combinations, striving for an optimal balance between nutrition and affordability. urthermore, leveraging sophisticated algorithms and formulae, the paper constructs a daily diet optimization model that takes into account a multitude of factors, achieving a harmonious blend of nutrition, taste, and economy [2]. To offer more holistic dietary advice, the research is extended to a one-week meal plan, designing three distinct optimization models tailored for both men and women. The resulting dietary plans not only fulfill nutritional needs but also consider economic factors, providing comprehensive dietary guidance for a week [3]. Building on this, the article compiles recommendations for a healthy and balanced diet, aiming to foster healthier and more scientific eating habits, thereby supporting individuals' overall development [4]. The research findings of this paper are primarily manifested in the successful development of a suite of daily diet optimization models that comprehensively consider protein quality, taste, and economy. These models not only ensure that daily food calorie intake for both men and women falls within recommended ranges and meets basic nutritional needs but also identify the most cost-effective breakfast recipe combinations through meticulous cost control and ingredient selection. Additionally, the study is further extended to one-week meal planning, with three different optimization models designed for men and women, focusing on maximizing protein amino acid scores, minimizing meal costs, and a combination of both. Based on these research findings, the paper also compiles healthy and balanced dietary recommendations, offering individuals scientific, economical, and reasonable dietary suggestions that will aid in the establishment of healthier and more scientific eating habits [5].

2. Optimization for problem analysis

Based on the analysis, a set of three-factor scoring formulas is derived and constructed:

$$100-\left[x_1-\frac{2400\times(12.5\%\pm 2.5\%)}{4}\right]-\left[x_2-\frac{2400\times(25\%\pm 5\%)}{9}\right]-\left[x_3-\frac{2400\times(57.5\%\pm 7.5\%)}{4}\right] \quad (1)$$

The calculations involve a combination of three variables: x1 represents the amount of protein consumed, x_2 represents the amount of fat consumed, and x_3 represents the amount of carbohydrates consumed.

This step centers on maximizing the protein's amino acid score as the key metric for evaluating the quality of a recipe [6]. To achieve this objective, the paper meticulously selects a single-dimensional multi-objective algorithm to develop a formula, which is then integrated with the amino acid mean score formula (daily recipe score).

$$S=\left[\frac{\left(\sum k\right)}{\left(\sum n\right)}\times 100\right] \quad (2)$$

The study led to the creation of a model that precisely captures the quality of the protein. Through iterative adjustments and refinements, an appropriate weight coefficient was identified to guarantee that the designed daily diets for both boys and girls were optimal with regard to protein intake. Subsequently, neural networks were employed to construct these recipes, followed by an in-depth evaluation to ensure they not only fulfilled the protein requirements but also maintained a balance in taste and overall nutrition.

The addition of economic factors to the above variables can be analyzed:

$$b=\frac{S}{a} \quad (3)$$

Here is a restated version of the given text:

In this context, A represents the total price, while B denotes the total quantity that can be acquired at the unit price. Consequently, this paper considers the design of recipes that balance both protein intake and economy. To achieve this, a multi-dimensional and multi-objective algorithm is employed, taking into account both the protein quality score and affordability.

With the objective of maximizing the amino acid score (AAS), a daily balanced diet is meticulously crafted. This involves optimizing food combinations using sophisticated models to ensure balanced nutrition, while precisely regulating the intake of proteins, fats, and carbohydrates. Given that vitamins and minerals were not explicitly included in the optimization process, a fruit is randomly incorporated into each meal based on dietary structure evaluation criteria. The recipe is then formulated, and MATLAB software is utilized to illustrate the corresponding variations in the diets of males and females, with AAS serving as the primary focus, as depicted in Figures 1 and 2.

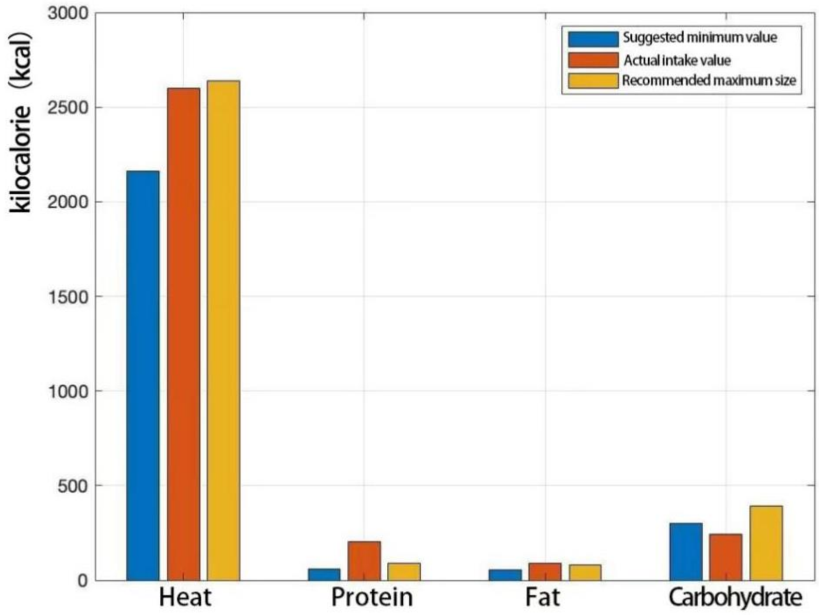

Figure 1. Establishment of a boy's diet with AAS as the first goal

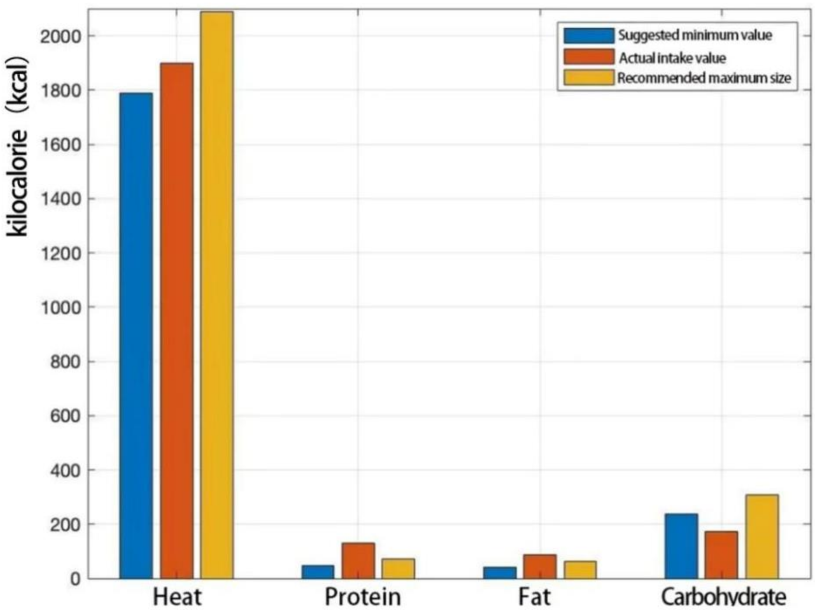

Figure 2. Establishment of a girl's diet with AAS as the first goal

By adding constraints and using linear algebra [7], the model formula is established:

$$y = w_1x_1 + w_2x_2 + w_3x_3 + \cdots + w_nx_n \tag{4}$$

Where w1, w2, w3,...... wn, which indicates the amount of nutrients in a food in grams; x1,x2,x3,…… xn represents the price of each food in grams per dollar.

Thus deriving the matrix:

$$W_{ij} = \begin{pmatrix} w_{11} & w_{12} & w_{13} & w_{14} & & w_{1n} \\ w_{21} & w_{22} & w_{23} & w_{24} & \cdots & w_{2n} \\ w_{31} & w_{32} & w_{33} & w_{34} & & w_{3n} \\ w_{41} & w_{42} & w_{43} & w_{44} & & w_{4n} \\ & & \vdots & & \ddots & \vdots \\ w_{m1} & w_{m2} & w_{m3} & w_{m4} & \cdots & w_{mn} \end{pmatrix} \tag{5}$$

Based on multiple linear equations, the most economical meal costs [8] are used to find the most economical options for breakfast, lunch and dinner.

In order to obtain a more comprehensive and scientific balanced dietary diet, this article can introduce the scoring indicators of other nutrients, such as total energy, fat, carbohydrates, etc. But here, to simplify the problem, this article only considers the total energy and protein intake. By optimizing the objective function, the balance between maximizing protein intake and economy can be derived:

$$(Ax + Dy) - (ax + by + cx + dx + ey + fy) \tag{6}$$

Where x and y represent the standardized intake of three meals a day for boys and girls, respectively, and A, D, A, B, C, D, E, F are the corresponding coefficients. By adding the constraint, the sum of the total intake of three meals a day for boys and girls is 1:x+y=1, and the protein intake of three meals a day for boys and girls does not exceed 10,000 units:

$$Bx + Ey \le 10000 \tag{7}$$

$$Cx + Fy \le 10000 \tag{8}$$

Where the intake of food cannot be negative, x≥0, y≥0.

In the process of constructing the daily recipe optimization model, this paper conducts an evaluation and comparative analysis of three different objective functions. First, the protein quality-first model ensures that the total daily calorie content of boys and girls is within the recommended range, thus ensuring adequate nutrient intake, which is essential for promoting good health. Secondly, the model with the goal of affordability, through fine cost control and ingredient selection, found the lowest price combination of breakfast recipes, which effectively met the economic needs of consumers, especially for consumers with limited budgets. Finally, under the guidance of multi-dimensional and multi-objective algorithms, the model that takes into account the quality and affordability of protein not only ensures sufficient nutrition and high taste, but also achieves economic rationality. This model takes into account a number of aspects to better meet the actual needs of modern consumers and shows excellent optimization results. Through the comparison of these three models, this paper can clearly see the advantages and applicable scenarios of each, which provides strong support for the personalized design of daily recipes.

Through the analysis of the above formula, it is possible to draw a line chart of energy and a funnel of protein content under different food indexes,this is shown in Figure 3, 4:

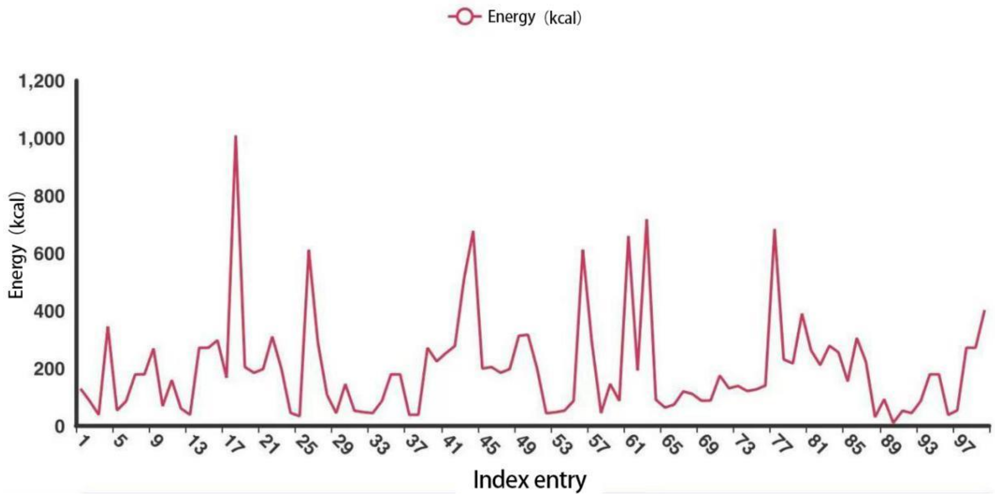

Figure 3. Energy line chart for each food

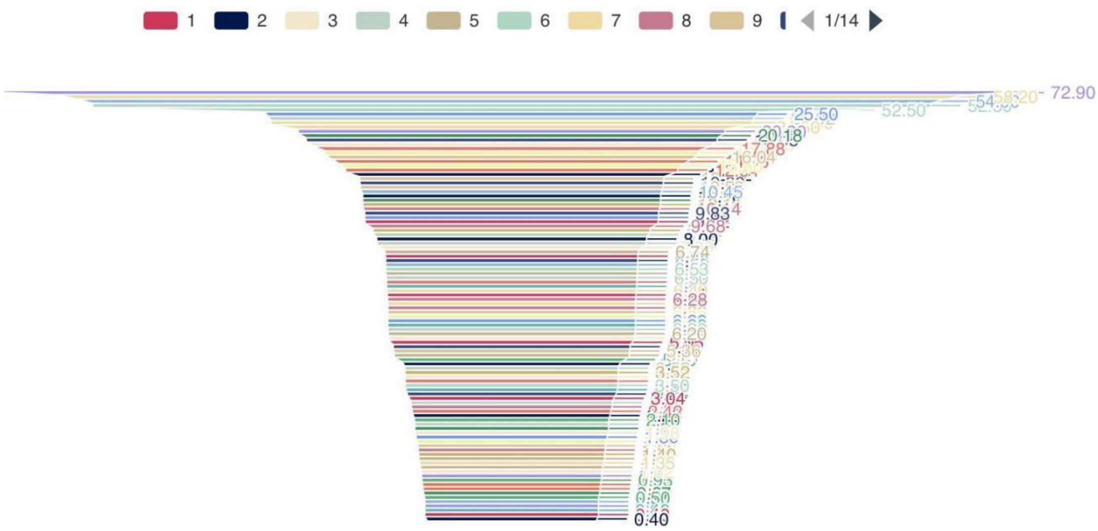

Figure 4. Funnel chart of protein content of each food

By combining the above analysis, the following process can be derived:

(1) Clarify requirements and constraints:

Nutrient requirements, which determine the total amount of nutrients such as proteins, carbohydrates, fats, vitamins, and minerals that are needed on a daily or weekly basis. Taste and dietary preferences, taking into account the user's taste preferences, food allergies or dietary contraindications, etc. Other constraints, such as budget constraints, diversity of food types, etc [9].

(2) Establish a food database

A food list, listing all the foods that are available; Nutrition facts, which provide detailed nutrition content data for each food, including proteins, carbohydrates, fats, vitamins and minerals, etc.; other attributes such as price, taste score, etc.

(3) Design a greedy strategy

Sort by Nutrient Needs: Sort foods based on the difference between their current nutrient needs and the nutrient content of the selected food. Prioritize foods that minimize the difference. Consider taste and variety: Consider the taste and diversity of food while meeting nutritional needs. For example, the present paper can set a threshold that lowers the priority of a food when it has been selected more than a certain number of times. Budget constraints: If cost is a consideration, factor price into your greed strategy and prioritize cost-effective foods.

(4) Greedy algorithm implementation

Initialization: Set initial nutrient requirements and budget limits (if costs are considered). The list of selected foods is empty at initialization.

Choose food: Choose a food from a food database based on greed strategy. Update nutritional needs and budget constraints (if costs are taken into account). Add the selected food to the Selected Foods list.

Repeat the choice: For each day or meal, repeat the above process of choosing foods until the nutritional needs are met or the budget limit is reached. If you can't find foods that meet the conditions, you may need to adjust your greedy strategy or relax certain restrictions. Optimize and adjust: Check that the recipe meets all needs and constraints. If you're not satisfied, try adjusting your food choices or greedy strategy, and then regenerate the recipe [10].

Based on the above process, you can then plot the cumulative sum of AAS for each meal.

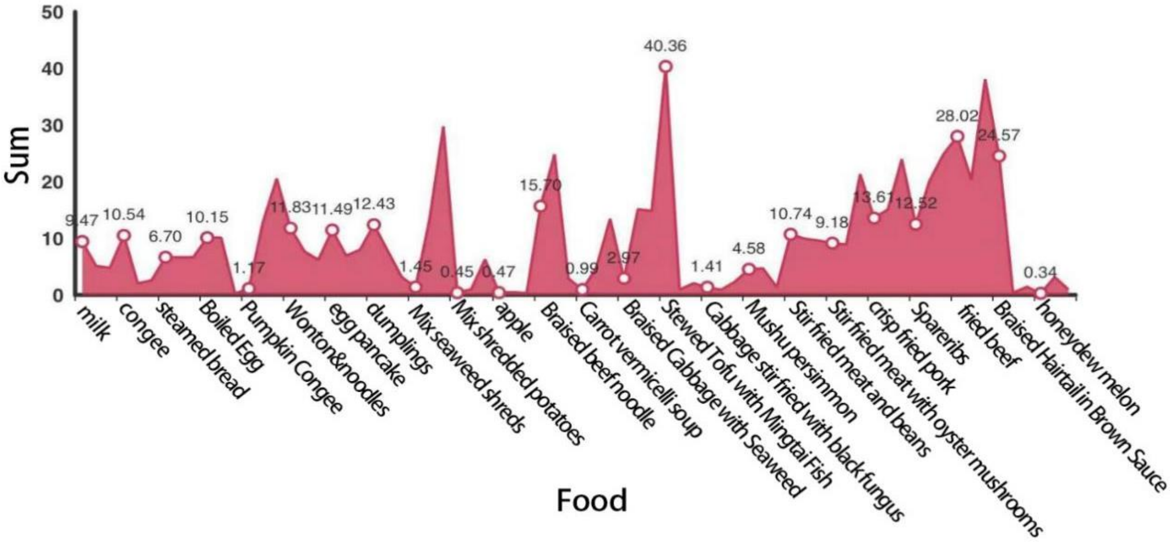

Figure 5. Cumulative sum of AAS area plot for each meal

In summary, in conjunction with Figure 5, when designing a balanced meal plan for seven days a week, this paper compares three objective functions: focusing on protein quality, economy, and comprehensive optimization of both. Protein quality optimization ensures that the protein ingested has a high nutritional value, but may overlook the balance of other nutrients or increase costs. Economic optimization aims to reduce the cost of a meal, but may sacrifice the balance of protein quality and other nutrients. Comprehensive Optimization balances the two and aims to provide a meal plan that is both nutritious and affordable. This model not only meets the needs of protein, but also takes into account the economy, which is more in line with the actual needs of modern people. Therefore, the integrated optimization model is the best choice to achieve a balanced meal design.

3. Conclusion

Based on the comprehensive analysis and research presented in this paper, the following conclusions can be drawn:

This study successfully developed an optimization model for daily diet recipes, focusing on balancing protein quality, taste, and economy. By employing advanced algorithms such as neural networks and genetic algorithms, combined with the amino acid scoring method, the research meticulously crafted meal plans that not only ensure adequate protein intake but also control costs and maintain a balance in overall nutrition. The models constructed take into account individual differences, including physiological characteristics and daily activity levels, to cater to the diverse needs of both men and women.

The optimization process resulted in three distinct meal plan models: one prioritizing protein quality, another emphasizing economy, and a third balancing both factors. These models were designed to fulfill nutritional requirements while being financially viable, providing comprehensive weekly meal guides that are both nutritious and cost-effective. Through this approach, the study addressed the challenges of unbalanced nutrition and inadequate consumption of essential nutrients, while also recognizing the financial constraints faced by individuals.

The research findings highlight the importance of amino acid intake in proteins and offer effective cost control methods. The meal plans compiled in this paper emphasize the balance between nutrition and economy, providing practical and sustainable dietary recommendations for daily use. These recommendations not only ensure nutritional adequacy but also align with economic considerations, making them feasible for individuals to adopt and maintain.

In conclusion, this paper contributes to the field of dietary optimization by providing a scientifically sound and practical proposal for healthy and balanced diets. The research findings offer individuals scientific, economical, and reasonable dietary suggestions that promote healthier eating habits and support overall development. Through this comprehensive approach, the study aims to enhance nutritional health, foster good eating habits, and provide a robust foundation for physical health and academic pursuits.

Future research directions can focus on further deepening the application of neural networks and other advanced algorithms in diet optimization to improve the personalization and accuracy of dietary formulas. At the same time, the optimization model was extended to include more comprehensive nutrient considerations, including vitamins, minerals, etc., to achieve a more balanced nutrient intake. In addition, we can also explore the specific impact of long-term dietary optimization on individual health, and how to promote the expansion of dietary optimization research to a wider range of practical applications through interdisciplinary cooperation and technical means such as big data and artificial intelligence, so as to provide the public with more scientific and personalized dietary guidance programs.

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