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ABSTRACT

This document summarizes the results of a project at Tulane University that was designed to adapt, test, and evaluate a computerized information and menu planning system utilizing linear programing techniques for use in school lunch food service operations. The objectives of the menu planning were to formulate menu items into a palatable, nutritionally adequate combination at minimum cost. The author did an empirical study of menu planning in the New Orleans Public Schools and found that the use of linear programing reduced raw food expenditures 13 percent over manual planning methods. (Author/DN)

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Title of project: A Study on Linear Programming Applications for the Optimization of School Lunch Menus

Project director: Irene K. Findorff U.S. Office of Education DHEW Region VII Dallas, Texas

Description of Problem

Due to the need for demonstrating to school lunch professionals the superiority of menu planning through linear programming techniques in order to provide meals to the participants at lower cost while satisfying nutritional requirements with greater precision than has been evidenced with manual procedures, a project was completed at Tulane University to adapt, test, and evaluate a computerized information and menu planning system for use in school lunch food service operations. Menu planning as a decision process affects the nutritional and palatability qualities as well as the cost of food served in institutions. The well-known objectives involved in the menu planning process are to formulate menu items into a palatable, nutritionally adequate, economical combination, that is, to satisfy a large set of simultaneous requirements for which the determination of the optimum condition has long been identified as a linear programming problem.

Scope of the Study

From both nutritional and financial viewpoints, it appeared worthwhile to explore the experimental development of a computer-assisted menu planning system for the school lunch program to provide optimum menus which would be more economical and possess greater satisfaction of exact nutrient constraints than has been feasible with the use of manual menu planning tools.

A data bank was created which contained nutrient, cost, and menu item information in computerized format.

These data were used to evaluate a 30-day cycle school lunch menu planned by conventional methods and to test a linear programming model used to plan menus with computer assistance. Menus planned by the manual and computerized procedures were compared with respect to total raw food cost and fulfillment of nutrient requirements.

Objectives Pursued

The overall objectives of the study included:

(1) to build and test a linear programming model suitable for planning menus on computer for the school lunch program which incorporated price, nutrient, and menu item frequency constraints derived from conventionally planned school lunch menus to formulate a feasible solution.

(2) to use the linear programming model to computer-plan a 30-day school lunch menu containing nutrient constraints based on one-third of the Recommended Dietary Allowances for the 10-12 year old child (1).

(3) to evaluate the computer-planned menus in terms of indicated raw food cost savings and satisfaction of nutrient and menu item frequency constraints.

(4) to disseminate the research findings obtained from the investigation to school lunch professionals so that:

(a) the superiority of linear programming as a menu planning tool could be demonstrated.

(b) the demand for advanced educational programs necessary for the understanding of a computer assisted menu planning system could be realized.

(c) the possibility of initiating a future pilot study within a school lunch feeding program to implement the computerized menu planning process could be entertained.

Methods Used

Coding procedures to formulate data for the IBM-CAMP system (2) were followed which involved the collection of quantitative nutrient, food item, and recipe information to create a school lunch data base.

A manually-planned 30-day cycle menu as used in the New Orleans Public Schools was obtained (3). Each item that appeared on this plan was coded to create a menu item master file which stored all pertinent information about a menu item including the ingredient list, ingredient purchase quantities, required weight and cost of each ingredient, recipe yield, portion size, cost per serving, physical attributes, dominant characteristics, and nutrient composition of a single serving of the recipe. In addition, recipes recommended by the U.S. Department of Agriculture for preparation of school lunches (4) were obtained and coded for inclusion in the menu item master file.

Price and purchase information for each recipe ingredient obtained from the Food Service Department of the New Orleans Public Schools (3) were coded and stored in a food item data file. Price data were updated prior to the evaluation of conventional menus and held constant for the computer assisted menu planning processes.

A computerized file of nutrient data based primarily on information found in U.S. Department of Agriculture, Handbook Number 8, Table 1 (5) was obtained and revised to include values for magnesium (5) and for vitamins B_6 and B_{12} derived from USDA Home Economics Research Report Number 36 (6).

A nutrient tally computer program (2) was employed to calculate the raw food cost and nutrient content of the 30 menus planned by manual methods.

A menu planning model (7,8) was adapted for use to computer-plan the school lunch menus utilizing data generated from the aforementioned files. This linear programming model with upper bounds can provide for 35 constraints subdivided as attribute, structural, nutrient, and special constraints, and for 400 menu items classified into nine categories. The program runs through off-line batch processing and produces a sequence of menus with desired variety while satisfying nutritional specifications on the average at minimum cost. The program is a chain of linked subroutines containing:

(1) a matrix generator program

(2) a linear programming code with implicit upper bounds

(3) optional subroutines for indifference and feasibility ranges

(4) a listing subroutine.

Three matrices were developed and employed to test the application of the linear programming approach to school lunch menu planning. These matrices represented data sub-sets of the menu item file information with the addition of separation ratings (i.e. the number of days that must elapse before the item may recur in a menu plan) and served to define the nutrient and structural requirements for the menu planning program.

Conventional- and computer-planned menus were compared with respect to total raw food cost and fulfillment of stipulated nutrient constraints.

Results Obtained

Traditionally, school lunch menus have been manually planned with respect to Federal reimbursement standards to fulfill requirements known as the Type A pattern. The Type A lunch provided minimally to participants a two-ounce serving of lean meat, poultry, fish or equivalent of such, a three-fourths cup serving of two or more vegetables or fruits, one slice of whole grain or enriched bread or suitable equivalent, one teaspoon of butter or fortified margarine, and one-half pint of whole, fluid milk. This pattern was designed as a tool to assist school lunchroom managers in the formulation of palatable, nutritious meals and provided for the development of a monitoring system to determine Federal and State reimbursement for the meal served. For example, if it could be shown that the daily school lunch menu met the Type A requirements, subsidy was automatic.

It was anticipated but never stated as a regulation that judicious use of the Type A pattern would result in menu plans that would contain one-third of the Recommended Dietary Allowances (1) for each respective age-group of school children. Guidelines were published and distributed to school lunch managers to encourage the achievement of this secondary nutrient goal through incorporation of selected nutrient-endowed foods in the weekly menu plan. Similarly, it was hoped that nutritional needs for different age-sex groups of children would be fulfilled by the expansion and/or contraction of portion sizes of food offered.

Current technology permits the rapid computation of nutrients contained in a meal or menu providing that accurate nutrient data are available. Consequently, consideration has been given to the possibility of planning school lunch menus according to a nutrient standard rather than attempting to select foods to fill out the former Type A pattern. Use of such a standard would permit exact achievement of nutrient goals particularly if computer assisted menu planning techniques were employed since the computer method allows the user to stipulate definite nutrient constraints.

Data obtained from the nutrient tally program included the daily raw food cost and daily nutrient composition of the 30-day conventional menu plan. The nutrient data represented values for food energy (calories), protein, fat, saturated and unsaturated fatty acids, magnesium, calcium, iron, vitamins A, B_6, B_{12}, C, thiamine, riboflavin, and niacin (Appendix, Table 1). The results of the present investigation demonstrate the ineffectiveness of the use of the manual tool, the Type A pattern, for planning school lunch menus to meet a nutrient standard. The conventionally planned 30-day Orleans Parish school lunch menu contained inadequate quantities of food energy (calories), iron and thiamine and excessive amounts of protein, calcium, vitamin A, riboflavin, niacin equivalents, and vitamin C when the daily average nutrient content of the menus was compared to the one-third value of the National Research Council recommendations (1) for the 10-12 year old child as stipulated by USDA to comprise a nutrient standard for school lunches (9).

A menu planning matrix was constructed which specified as constraints the exact nutrients as were found in the conventional school lunch Type A pattern meals served to participants in Orleans Parish. Also, the frequency of service of various menu items was paralleled to that observed in the New Orleans schools. Only menu items which appeared in the 30-day conventional cycle were included in the matrix. This matrix information was utilized to computer-plan a 30-day menu. The linear programming solution using identical menu item data as were found in the manual Type A plan satisfied all nutrient constraints at a lesser raw food cost. The average daily cost of the manual plan was 20.43 cents and of the computer menu plan, 17.70 cents (Appendix, Table 2).

A second computer menu plan was obtained using matrix data which specified one-third of the Recommended Dietary Allowances (1) for the 10-12 year old child as nutrient constraints with the exception of protein; the protein requirement was entered as one-half of the respective allowances. The nutrients stipulated for this second matrix represented increases in the quantities of calories, iron, and thiamine and decreases in the levels of protein, calcium, vitamin A, and riboflavin when the values were compared to data contained in the first matrix. This second matrix also included menu items from the USDA recipe file (4) as well as the original Orleans Parish items derived from the conventional menu plan. The average daily raw food cost of this computer menu plan was 17.91 cents reflecting a 2.52 cent savings when compared to the conventional plan (Appendix, Table 2). It is interesting to note that even though the protein constraint was lower, the cost of this computer menu plan increased due to the satisfaction of the increased iron requirement. The stipulation for protein, and in fact all nutrients, was expressed as a greater than or equal to inequality. This second computer menu plan actually contained more protein than obtained when only the conventional data and requirements were used (Plans 1 and 2, Appendix, Table 2). Iron was shown to be a binding nutrient constraint when the menu plan solution was evaluated.

The data were manipulated in an effort to obtain a third menu plan soltuion which would possibly show additional raw food cost savings. The structure of the third matrix differed from the second in the following ways:

(1) the caloric, thiamine, and riboflavin nutrient constraints were decreased to represent recent recommendations from USDA (9).

(2) the protein constraint was decreased to reflect one-third of the Recommended Dietary Allowances (1) for the 10-12 year old child.

(3) requirements for dominant items were changed to increase menu variety. For example, the constraint for potato-containing items was changed from less than or equal to one to greater than or equal to five occurrences permitted to enter into the 30-day menu solution.

(4) upper bounds for all menu items were increased by one, a procedure which relaxes restrictions imposed on the data.

(5) a dominant characteristic code was attached to all bread-contributing entrees which by nature of its incompatability action would force more plain bread items into the computer solution.

The menu plan obtained from this third data sub-set showed a daily raw food cost of 17.74 cents which represented a 2.69 cent cost saving from the original conventional plan (Appendix, Table 2).

Results obtained from the three linear programming solutions indicate that there is a potential for at least a thirteen percent savings in raw food cost with simultaneous satisfaction of nutrient and palatability constraints if the computer assisted technique for school lunch menu planning would be implemented.

Dissemination of the findings of this investigation was achieved through formal presentations at the following professional meetings:

(1) Third International Congress of Food Science and Technology, Washington, D.C., August 14, 1970.

(2) ORSA Annual Meeting, New Orleans, Louisiana, April, 1972.

(3) Louisiana School Food Service Association, Baton Rouge, Louisiana, June 14, 1972.

The need to provide advanced educational and training programs to prepare school lunch professionals for utilization of computer assisted menu planning systems was emphasized as part of the following programs which were not supported by this grant:

(1) USDA-Training Course, Dade County Public Schools, Miami, Florida, January 31 - February 11, 1972.

(2) USDA-Training Course, Memphis City Schools, Memphis, Tennessee, April 17 - 28, 1972.

(3) Computer Applications in Food Service Management and Dietetics, Tulane University, New Orleans, Louisiana, June 9, 1972.

Future dissemination activities emanating from this work include two presentations scheduled for the East Baton Rouge School Lunch Board, Baton Rouge, Louisiana, November 21, 1972.

Highlights of Findings

In 1967, the U.S. Department of Agriculture initiated a study to test the interpretation of the Type A pattern to evaluate whether the basic lunch as served did provide adequate quantities of nutrients to satisfy the one-third Recommended Dietary Allowance values (1) for 10-12 year old children (10,11). The survey encompassed 300 schools from 19 states selected to represent the United States as a whole. Six-thousand lunches as served were analyzed for calorie and nutrient content and the results were compared with both one-third and one-fourth of the 1968 recommended allowances.

The lunches from the 300 schools on the average met or exceeded the nutritional goal of one-third of the recommended allowance for all nutrients except iron and magnesium and tended to fall below the goal in food energy (calories). When the results were appraised by districts - lunches from a number of schools failed to provide sufficient nutriment to meet the requirements for food energy and for certain vitamins and minerals particularly vitamin A, vitamin B6, iron and magnesium.

Since only conventional menu planning tools were available, the U.S. Department of Agriculture could only recommend that foods considered rich sources of vitamin A and iron be served to school lunch participants more frequently than suggested previously; additional quantities of vitamins A and D were provided by fortifying commodity dry milk solids with these nutrients; also school lunch managers were advised to serve recommended portion sizes of items in an attempt to alleviate the caloric deficit revealed from the analysis of the lunches.

The results of the USDA study and of the current investigation do indeed confirm the suspicion that meal patterns and guidelines cannot be used effectively to achieve precise satisfaction of nutrient stipulations. School lunch menu items carry a designation that categorize the individual recipe according to the particular meal pattern component provided. For example, a single portion of the USDA recipe for Braised Beef referred to as a "protein-rich food with vegetable" furnishes the equivalent of two ounces of cooked, edible meat, and one-fourth cup of vegetable; nutrient calculations for this serving of the Braised Beef are not included. The process of insertion of items into meal patterns to construct menus has at least two shortcomings inasmuch as neither the complete nutritional analysis of the total recipe or its respective single portion nor the mathematical solution of equations is utilized. The methodology of conventional menu planning possibly hinges upon the human ingenuity of balancing sets of random variables by trial and error methods. Balancing meals for more than one nutrient is a problem of solving simultaneous systems of equations which may involve dozens of constraints and hundreds of variables, so that this strictly mathematical problem can be solved accurately only by computer. The methodology applied to the computer-planned menus, therefore, sets the absolute standard of the computation subject to the accuracy of specifying any given set of nutritional data and constraints.

Since linear programming is a mathematical optimization technique concerned with the most efficient allocation of limited resources to meet given objectives, maximum quantities of government distributed commodity food items appeared in the solution of the computerized menu planning problem. With the provision of improved satisfaction of exact nutrient constraints at a relatively lesser cost, it can be predicted that despite continually rising food prices, more meals can be served, particularly the reduced- or non-cost-meals that are needed to foster the improvement of nutritional status among children of poverty, without increasing the total budget of the school lunch operation.

Significance and Implications

The results obtained from the present study show the potential for a thirteen percent savings in school lunch expenditures for raw food if computer assisted menu planning techniques were to be employed. Estimates obtained from the American School Food Service Association reporting financial needs for the 1970 school year indicated that 807.8 million dollars were requested and yet only 504 million dollars were appropriated by the Congress of the United States for the National School Lunch Program (12). The program, thus, had to operate at a deficit. If computer assisted menu planning systems had been implemented at this time, the financial deficit could have been reduced. The raw food cost of the conventional menu plan used in Orleans Parish was 20.43 cents per day; the average cost savings achieved with the computer menu plans was 2.65 cents per day. Extending this savings to the 25 million school children reached daily by the National School Lunch Program would save the operation 662.5 thousand dollars per day or 1.3 million dollars for a two-day period. The computer assisted approach to school lunch menu planning goes beyond raw food cost savings with improved nutritional control and child satisfaction to provide an efficient tool for the management of child feeding programs (13).

Recommendations

Results of the present study served as a basis for development of additional programs. The following recommendations emanating from this work are elicited even though it is realized that some of these suggestions are currently in effect:

(1) use of a nutrient standard along with computer assisted menu planning procedures to formulate school lunch menus

(2) develop a national data bank which would contain the basic information required for the computer assisted menu planning program

(3) create a clearing center where new and revised nutrient information can be evaluated to maintain an accurate and reliable nutrient data file

(4) implement the reported computerized system in an operating school food service operation on a trial basis to demonstrate the effectiveness in actual practice

(5) offer training programs to educate the school lunch professionals concerning the use of this computerized menu planning methodology.

References

(1) National Academy of Sciences - National Research Council. Recommended Dietary Allowances, Revised 1968. Publ. No. 1694: Washington, D.C. 1968.

(2) IBM Corporation: Contributed Program Library. System/360. Computer Assisted Menu Planning. 360D-15.2.013. Date of submittal: September 23, 1969.

(3) Personal communications: Food Service Department, New Orleans Public Schools, Mrs. Mary C. Sherwood, Director, New Orleans, Louisiana. August, 1970 through February, 1971.

(4) U.S. Department of Agriculture. Quantity Recipes for Type A School Lunches. Program Aid 631. U.S. Government Printing Office: Washington, D.C. 1971.

(5) Watt, B.K. and Merrill, A.L. 1963. Composition of Foods, Raw, Processed, Prepared. Agriculture Handbook No. 8, U.S. Department of Agriculture. U.S. Government Printing Office: Washington, D.C.

(6) Orr, M.L. 1969. Pantothenic Acid, Vitamin B_6, and Vitamin B_{12} in Foods. Home Economics Research Report No. 36, U.S. Department of Agriculture. U.S. Government Printing Office: Washington, D.C.

(7) Dennis, L.C. and Balintfy, J.L. Computerized Dietary Information System. Volume V. Single Stage Menu Planning Program. To be published.

(8) Personal communications: Lyman C. Dennis II, President, Management Optimization Systems, Inc., Suite 1136, National Bank of Commerce, New Orleans, Louisiana. April, 1970 through July, 1972.

(9) Food and Nutrition Service, U.S. Department of Agriculture. Meal Standard for School Lunches (Preliminary for Review). February, 1971.

(10) U.S. Department of Agriculture, Agricultural Research Service and the Consumer and Marketing Service. Nutrients in Type A School Lunches. 1969.

(11) Murphy, E.W., Grossman, E., and Forziati, F.H. The nutritive content of Type A lunches. School Lunch Journal 22:11-18, 1968.

(12) Personal communication: Louise A.K. Frolich, Field Coordinator, American School Food Service Association, Denver, Colorado. May, 1971.

(13) Gelpi, M.J., Balintfy, J.L., Dennis, L.C., and Findorff, I.K. Integrated nutrition and food cost control by computer. J. Am. Dietet. Assn. (to be published, Fall, 1972).

Appendix Table 1

Nutrient Content and Raw Food Cost of a 30-Day Conventionally Planned School Lunch Menu Cycle*

Nutrient	Value per day
Calories	786.
Protein (gm)	27.8
Fat (gm)	38.6
Saturated Fatty Acids (gm)	14.5
Unsaturated Fatty Acids 1 (gm)	12.4
Unsaturated Fatty Acids 2 (gm)	2.7
Magnesium (mg)	67.5
Calcium (mg)	472.5
Iron (mg)	3.8
Vitamin B_6 (mg)	2.725
Vitamin B_{12} (mcg)	1.274
Vitamin A (I.U.)	2385.
Thiamine (mg)	.387
Riboflavin (mg)	.792
Niacin (mg equiv)	8.465
Vitamin C (mg)	20.0
Raw Food Cost (cents)	20.43

*Conventional menu plans were obtained from the New Orleans Public Schools as served to participants September 8 - October 16, 1970.

Appendix Table 2

Nutrient Content and Raw Food Cost of Three Computer Menu Plans*

Nutrient Constraint	Plan 1 Required per day	Plan 1 Actual per day	Plan 2** Required per day	Plan 2** Actual per day	Plan 3 Required per day	Plan 3 Actual per day
Calories	≥ 786.	788.	≥ 835.	879.	≥ 800.	867.
Protein (gm)	≥ 27.8	27.8	≥ 22.5	29.2	≥ 17.0	29.1
Calcium (mg)	≥ 472.	496.	≥ 400.	479.	≥ 400.	491.
Iron (mg)	≥ 3.8	3.8	≥ 5.0	5.0	≥ 5.0	5.0
Vitamin A (I.U.)	≥2385.	2693.	≥1500.	4521.	≥1500.	4649.
Thiamine (mg)	≥ .387	.39	≥ .43	.43	≥ .41	.42
Riboflavin (mg)	≥ .792	.80	≥ .43	.90	≥ .41	.90
Cost***						
Raw Food Cost (cents)		17.70		17.91		17.74
Cost Savings (cents)		2.73		2.52		2.69
Cost Savings (percent)		13.36		12.33		13.17

*Menus were planned for a 30-day period.

**Requirement based on one-third of the Recommended Dietary Allowances (1) for the 10-12 year old school child with the exception of protein; the protein requirement represented one-half of the respective allowance.

***Cost saving values based on difference between cost of computer menu plan and the conventional menu plan (20.43 cents per day). Food price information was held constant for the evaluation of conventional menus and the planning of computer menus.