Least-Cost Diets in Cristalina, Goiás, Brazil*

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SUMMARY

Nutritionally inadequate diets are commonly attributed to low per capita incomes. This study presents two linear programming solutions examining possibilities of obtaining adequate diets through reallocation of food expenditures. One minimizes cost, considering only caloric and nutrient restrictions, while the second also incorporates consumer's tastes and preferences. Results indicate adequate diets, reflecting many of the consumer's tastes and preferences, can be obtained by reallocating food expenditures. Nutrition education programs appear to have a major role in low-income countries and linear programming can be used to obtain guidelines for programs which improve nutritional levels without increasing food costs.

Two-thirds of the world's population lives in countries where the average national diet is nutritionally inadequate in calories, proteins, vitamins or minerals (1). In these countries, total food availability is a major factor limiting the quantity and quality of diet. Brazil is not limited by food availability, however, one-third of Brazilian diets in 1965 were deficient in calories and two-thirds were deficient in protein, vitamins, or minerals (2). The poor nutritional level of these diets is commonly attributed,

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in part, to low levels of income preventing people from buying foods necessary for an adequate diet.

This note reports on a study (3) examining the possibility of attaining a nutritionally adequate diet by reallocation of current food expenditures. More specifically, the study had three objectives:

1. determine the least-cost nutritionaly adequate diet in the area studied;
2. determine the least-cost nutritionally adequate diet subject to restrictions reflecting consumer's tastes and preferences; and
3. compare the costs of these diets and actual expenditures on food.

MATERIALS AND METHODS

Data was obtained from a study (4) in Cristalina, Goiás, by the Comissão Nacional de Alimentação (CNA). Cristalina, a city of 5,800 in 1960, is located 118 Km. south of Brasília in central Brazil at an altitude of 1250 m. The climate is dry and average maximum and minimum temperatures are 28º and 17º C. respectively. Mining of quartz crystal is the principal economic activity in the area, followed in importance by agriculture.

Twenty-three randomly selected families living in the suburban area were visited daily for seven days in December, 1966. Information was obtained on the sex, age and weigth of each family member, type and quantity of food consumed, prices paid for food purchased, family income, home food production, and other socio-economic information. On the basis of this information, families were classified in three socio-economic classes by the CNA.

The average family had about 6 members and a monthly family income, [1] of NCr$145.16. [2] About 50 percent of the average monthly family income was used for food and 93 percent of the food was purchased (Table 1). The "very poor" class appears to have spent more than their family income on food during the period studied, but this may be due to the

1. The monthly family income included only money income and the value of home produce. Gifts such as food or housing and other charity were not included - 4 families received gifts of housing.
2. In December, 1966, the exchange rate was NCr$2.2 (new cruzeiros) per U.S. dollar.

TABLE No. 1

MONTHLY FAMILY INCOME, VALUE OF FOOD CONSUMED AND PERCENT OF INCOME USED FOR FOOD BY SOCIO-ECONOMIC CLASS IN CRISTALINA, GOIÁS, 1966

Socio-Economic Class	Number of Families	Number of People	Monthly Family Income[a] (NCr$)	Monthly Value of Food Consumed[b] (NCr$)	Percent of Family Income Used for Food	Percent of Food Purchased
Very Poor	5	27	69.00	77.69	112.6	90.9
Poor	13	79	115.35	92.55	80.2	94.1
Well-to-do	5	27	321.91	131.66	40.9	94.9
Average[d]	23[c]	133[c]	145.16	97.77	50.3	93.1

a) Monthly Family Income included money income and value of home-produced food products.
b) Monthly Value of Food Consumed includes money spent and value of home-produced food products.
c) Total.
d) Weighted averages.

relatively short period studied and exclusion of gifts. [3] The "poor" class spent about 80 percent of their income on food and the "well-to-do" class spent about 41 percent of their income on food. The absolute value of food consumed by the "well-do-do" class was almost double that of the "very poor" class.

The nutritive value of the foods consumed by the families studied was computed and compared with the recommended diet allowances. The recommended allowances were determined by the age, sex and weight of the individual family members with corrections for temperature and environmental factors. [4] The diet consumed by the average family studied failed to meet any recommended dietary allowances for the nutrients considered

3. The monthly money income of the "very poor" class was slightly less than the minimum monthly salary in the area of NCr$66.00.
4. The differences in the recommended levels of nutrients for the various socio-economic classes are due solely to the age, sex, weight composition of the classes.

TABLE No. 2

AVERAGE DAILY PER CAPITA CONSUMPTION, RECOMMENDED DIETARY ALLOWANCES a) AND PERCENT OF ADEQUACY OF CALORIES AND NUTRIENTS FOR VARIOUS SOCIO-ECONOMIC CLASSES IN CRISTALINA, GOIÁS, 1966

Calories and Nutrients	Socio-economic Class			
	Very Poor	Poor	Well-to-do	Average b/
Calories (Cal.)				
Observed	1784	1787	2147	1864
Recommended	1855	2014	2302	2042
% Adequacy	96%	91%	93%	91%
Protein (g.)				
Observed	35.7	48.5	58.2	47.8
Recommended	51.7	58.8	68.2	59.3
% Adequacy	69%	82%	85%	81%
Calcium (mg.)				
Observed	123	202	223	190
Recommended	881	987	1072	983
% Adequacy	14%	20%	21%	19%
Iron (mg.)				
Observed	7.9	9.4	10.7	9.4
Recommended	10.6	11.2	12.2	11.3
%Adequacy	75%	84%	88%	83%
Vitamin A (I.U.)				
Observed	2037	1115	5909	2357
Recommended	4025	4251	4471	4249
% Adequacy	51%	26%	132%	55%
Thiamin (mg.)				
Observed	0.54	0.70	0.97	0.72
Recommended	0.93	1.01	1.15	1.02
% Adequacy	58%	69%	84%	71%
Riboflavin (mg.)				
Observed	0.41	0.59	0.78	0.59
Recommended	1.29	1.47	1.70	1.48
% Adequacy	32%	40%	46%	40%
Niacin (mg.)				
Observed	6.9	8.5	11.8	8.9
Recommended	9.3	10.1	11.5	10.2
% Adequacy	74%	84%	103%	87%
Vitamin C (mg.)				
Observed	14	30	72	36
Recommended	51	57	65	58
% Adequacy	27%	53%	111%	62%

a) Calculated from "Recommended Dietary Allowances", National Research Council, 1958. Differences in recommended levels of nutrients for various socio-economic classes are due solely to the age, sex, and weight composition of the classes.

b) Weighted averages.

SOURCE: CNA (4).

(Table 2). The diets for all socio-economic classes were lowest in calcium, riboflavin and vitamins A and C. Diets tended to improve as the socio-economic level of the families studied increased and the "well-to-do" families met the recommended allowances for niacin and vitamins A and C.

During the period of study, 100 foods were consumed by the families studied. Rice, sugar, dry beans and coffee were consumed by all of the families and other foods consumed by a large proportion included bread, mandioc flour, lard, beef and milk. A wide variety of vegetables were consumed, but only "chuchu" [5] and garlic were consumed by over 60 percent of the families.

The least-cost nutritionally adequate diet was determined by linear programming. In the first model, 11 calorie and nutrient restrictions, based on the average dietary allowances for the families studied, were formulated for a family of six for a one-week period. Later, additional restrictions to limit the maximum and minimum amounts of various foods consumed were added. Consumption of salt was included in both diets. The calories, nutrients and prices of 87 foods consumed were also included in the model and a solution was obtained that minimized the cost of the diet subject to the restrictions specified. [6]

RESULTS

The least-cost adequate weekly diet for a family of six included 6 foods and had a cost of NCr$11.99 (Table 3). Of the foods included in the minimum cost solution, only mandioc flour and dry beans were consumed by 70 percent or more of the families studied. The other foods were consumed by less than 10 percent of the families studied. However, it should be noted that corn and collard greens are commonly consumed in other parts of Brazil.

The least-cost adequate diet, although inexpensive, is not highly palatable. [7] To improve its palatability, additional restrictions reflecting tastes and preferences of the consumers were

5. "Chuchu" (Sechium edule) is a pear-shaped, light green vegetable. Called chayote in English, it is almost unknown in the United States.
6. The number of foods considered was reduced to 87 as some foods were of very similar composition, available for only very limited periods of the year, or had an unknown nutrient composition.
7. Similar problems have been encountered in determining least-cost diets in the United States. An alternative manner of formulating restrictions was used by Smith (5).

formulated. All foods consumed by 50 percent or more of the families studied had minimum consumption levels specified. In the final diet, 15 additional restrictions limiting amounts of various foods consumed or forcing consumption of minimum amounts of other foods were used in addition to restriction for calories and nutrients.

Including restrictions reflecting tastes and preferences of the consumers increased the number of foods from 6 to 17 and the cost from NCr$11.99 to NCr$18.26 (Table 4). This diet, although including some foods not widely consumed in Cristalina, appears more palatable than minimum cost diet. It would probably be difficult to convince families in Cristalina to consume this diet, but several of the foods not widely consumed in Cristalina are consumed by much of the population in other areas of Brazil.

TABLE No. 3

LEAST-COST ADEQUATE WEEKLY DIET FOR A FAMILY OF SIX IN CRISTALINA, GOIÁS, DECEMBER, 1966

Foods	Quantity Kg.	Cost NCr$
Mandioc flour	14.868	3.82
Beef lungs	10.234	3.07
Coconut oil	1.992	2.24
Collard greens	6.729	1.79
Corn	1.960	0.78
Dry Beans	0.470	0.26
Salt	0.204[a]	0.06
TOTAL COST	------	12.02

a) Minimum restriction based on actual consumption.

The least-cost adequate diet represents a substantial savings in food costs for all socio-economic classes (Table 5). Savings for the "very poor" class were about NCr$25.46 and the cost of food was reduced from 112.6 percent of family income to about 76 percent. Savings for the other socio-economic classes were even greater. Including restrictions reflecting tastes and preferences of the consumer increased cost of the least cost diet by

TABLE No. 4

LEAST-COST ADEQUATE WEEKLY DIET FOR A FAMILY OF SIX WITH TASTE AND PREFERENCE RESTRICTIONS, CRISTALINA, GOIÁS, DECEMBER, 1966

Food	Quantity Kg.	Cost NCr$
Mandioc flour	4.200[c]	1.08
Beef lungs	1.073	0.32
Coconut oil	[c]	
Collard greens	2.100[c]	0.56
Corn	2.100[c]	0.84
Dry beans	2.293[d]	1.27
Salt	0.204[a]	0.06
Coffee (ground)	0.684[a]	0.31
Sugar	3.599[d]	1.09
Rice	2.970[b]	2.13
Lard	0.648[a]	0.81
Bacon	0.584	0.69
Beef Kidney	0.132	0.13
French bread	0.600[b]	0.54
Milk	21.415	5.07
Beef	1.200[b]	2.88
Summer squash	0.400[b]	0.15
"Chuchu"	0.600[b]	0.19
Garlic	0.050[b]	0.14
TOTAL COST	------	18.26

a) Minimum restriction based on actual consumption.
b) Minimum restriction formulated to provide a number of portions of these foods per week.
c) Maximum quantity permitted in the model.
d) The minimum quantity of these foods required was less than the quantity included in the solution.

TABLE No. 5

ACTUAL FOOD COSTS AND COSTS OF LEAST-COST ADEQUATE DIETS PER MONTH FOR A FAMILY OF SIX AND AS A PERCENTAGE OF MONTHLY FAMILY INCOME BY SOCIO-ECONOMIC CLASS IN CRISTALINA, GOIÁS, DECEMBER, 1966

Socio-Economic Class	Monthly Family Income NCr$	Actual Food Costs		Monthly Cost of Least-Cost Diet[a]		Monthly Cost of Modified Least-Cost Diet[a]	
		NCr$	Percent of Family Income	NCr$	Percent of Family Income	NCr$	Percent of Family Income
Very Poor	69.00	77.69	112.59	52.23	75.70	79.34	114.99
Poor	115.35	92.55	80.23	52.23	45.28	79.34	68.79
Well-to-do	321.91	131.66	40.90	52.23	16.23	79.34	24.65
Average	145.16	97.77	67.35	52.23	35.98	79.34	54.66

a) A month consists of 4.345 weeks.

little more than 50 percent. This diet had a higher cost for "very poor" class than their actual food costs, but represented substantial savings for the other classes.

IMPLICATIONS

Results, although based on a very limited sample, indicate that nutritionally adequate diets can be obtained by reallocation of food expenditures in Cristalina. The cost of a nutritionally adequate diet is less than actual food costs even for families in the "very poor" class. Including restrictions reflecting consumer tastes and preferences increases the cost of the diet, but an adequate diet including all of the foods consumed by 50 percent or more of the families is only slightly more expensive than average actual expenditures on food by "very poor" families.

Although it is not suggested that these particular least -cost diets should be adopted by families in Cristalina, the recults indicate that nutrition education programs do have a major role in low-income countries. Linear programming is a technique by which least-cost diets can be determined rapidly for various areas, while incorporating the tastes and preferences of consumers. Changes in prices of the foods considered, such as occurs with seasonally available products, wil change the types and quantities of foods making up the least-cost diet. However, results of linear programming studies of this type can be used to obtain guidelines for consumer education programs that will improve the nutritional level of diets without increasing food expenditures.

RESUMEN

Dietas de costo mínimo en Cristalina, Goias, Brasil

Las dietas nutricionalmente inadecuadas son corrientemente atribuidas a bajos ingresos per cápita. El presente estudio ofrece dos soluciones logradas mediante la programación lineal que examinan las posibilidades de obtener dietas adecuadas mediante un reajuste de los gastos por adquisición de alimentos. En una de ellas se busca lograr el costo mínimo considerando solo restricciones calóricas y de nutrientes mientras que la otra incorpora además la preferencia y el gusto del consumidor. Los resultados indican que es posible obtener dietas adecuadas, compatibles con muchos de los gustos y preferencias del consumidor, mediante un reajuste de los gastos. Aparentemente los programas de educación nutricional desempeñan un importante papel en países de bajos ingresos y puede usarse una programación lineal para obtener directrices en programas que mejoren los niveles de nutrición sin aumentar el costo de los alimentos.

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