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THE POTENTIAL CONTRIBUTION OF AGRICULTURAL PRODUCTION RESEARCH TO HUMAN WELFARE THROUGH IMPROVED NUTRITION - A CASE STUDY

By

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The overall allocation of resources to agricultural production research related to developing countries is usually being justified, at least in part, on the basis of existing and/or prospective future deficiencies in human nutrition. Once the overall resource allocation has been justified, however, project resource allocation is usually done on the basis of other factors such as farm returns, etc. and the expected and obtained impact of the research on human nutrition receives little analytical attention. Attempts by economists to seek information to help direct agricultural production research in such a way as to improve its impact on human nutrition are few and far between 1/. Other "more important" issues, such as the impact of the research on net farm revenues, labor and land productivity, foreign exchange earnings and the agricultural sector as a promoter for general economic development tend to occupy the minds of the economists.

Furthermore, it is interesting to note that although serious attempts are being made to explain successful economic development in terms of improved human welfare, improving human nutrition by itself is not generally accepted as one of the principal objectives of development programs. It is argued that, with a few minor exceptions, improving nutrition

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1/ Recent attempts to increase the quantity and quality of protein in staple foods through plant breeding and fortification have created some interest among economists, but most economic research related to the subject has been of a descriptive and global nature with very limited utility for research resource allocation.

has a very small multiplier effect on general economic growth, hence does not help create self-sustained economic development 2/.

The primary objectives of this paper are (1) to discuss the importance of improved nutrition in economic growth and human welfare and (2) to demonstrate how economic analysis may contribute to an improved agricultural research resource allocation if improved human nutrition is a goal. The empirical analysis is carried out as a case study of the potential impact of agricultural production research on human nutrition of the population of the city of Cali, Colombia. The impact of hypothetical supply expansions of selected food commodities on the intake of calories and protein of a group of randomly selected consumers at various income levels is estimated. The impact of supply expansions is compared to that of increasing consumer incomes.

Data for the analysis were obtained from a stratified random sample of households on a number of factors including family size and age distribution, family incomes, quantity consumed of each of all major foods during a given time period and prices paid for the foods consumed. The sample households were divided into five economic strata and the following variables were estimated for each strata: (1) present level of consumption of each of certain selected foods, (2) present level of calories and protein intake, (3) present expenditures on each of the foods, and (4) income, price and cross elasticities for each of the foods. These variables were then used to estimate the impact of se-

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2/ Review of a number of widely used textbooks on economic development revealed that these books generally do not explicitly state improved nutrition of the present generation as a major development goal.

lected hypothetical levels of increase in the production of each of certain selected foods on the calorie and protein intake by income strata. Finally, the nutritional impact of (1) expanding food production at a constant demand function and (2) expanding food production and consumer incomes so as to maintain food prices constant, i.e. the impact on nutrition brought about by increased consumer real income due to reduced food prices and that which is due to increased consumer earnings were estimated.

The paper is divided into three parts. First, the role of improved nutrition in economic growth and human welfare is discussed briefly. Then follows a discussion of the results of the quantitative analysis outlined above and the paper concludes with a discussion of the implications for agricultural production research if the nutritional aspects of expanded food production were to play a greater role in the allocation of agricultural production research resources.

NUTRITION, GROWTH AND WELFARE

Nutrition and economic growth

For the purpose of this discussion, it is essential to distinguish between the impact of expanded food production on economic growth and the impact of improved nutrition. While the role of expanded food production in the economic growth process has been widely documented (18), no general agreement has been reached as to the role of improved nutrition as a growth factor. Likewise, it is important to distinguish between increased food consumption and improved nutrition. The impact of

increasing food consumption on nutrition will depend on the nutritional value of the foods concerned as well as the nutritional level of the consumer. Increased food consumption among high income consumers may have little or no impact on nutrition.

While formation of physical capital was regarded by the classical and the neo-classical economic growth theory as the key requirement for growth, the neo-classical theory did emphasize the importance of technological change in the growth process (3). It was not until recently, however, that "investment in man" became to play an important role in growth theory (19). Still, the capital/output model was not abandoned. Instead, the concept of capital accumulation was widened to include, besides physical investment, "investment in man", sometimes labelled "investment in human resources" (19, 3). Since the wide variety of factors that might play a significant role in improving human resources was difficult to quantify, one or more factors were singled out to represent the group. Investment in education is the factor most frequently used for this purpose.

Considering man exclusively as a production resource we may define the objective of investment in human resources strictly as improving the resource productivity. However, even under this assumption it is obvious that, in addition to education, we must include in our growth model health, nutrition and maybe other variables such as motivation and desires. Obviously, a certain correlation exists among these variables.

Improved nutrition serves as an economic growth factor through increasing productivity of the labor force and entrepreneurs either directly,

or indirectly through improved health and mental capacity. A considerable amount of empirical evidence exists on the relationship between nutritional level and labor productivity. Leibenstein (12, p. 65) reports that a study carried out in Germany in the 1940s showed that a 21 percent increase in total calorie intake by construction workers resulted in an almost 50 percent rise in output. Oshima (20, p. 27) estimated that a 20 percent increase in total calorie intake by the average adult Asian would increase the capacity to work by more than 40 percent.

The impact of improved nutrition on labor productivity may be direct, as in the above mentioned studies, or it may be indirect through improved health and mental development. While under and malnutrition 3/ by itself may be considered a disease such as for example kwashiorkor, which is due to severe protein deficiencies, maybe the most important consequence of under and malnutrition is reduced disease resistance. Myrdal (19, p. 1549) states that "in all South Asian countries and particularly in the biggest and poorest of them, India and Pakistan, a major cause of ill health is serious undernutrition and malnutrition among the masses of the people". Belli (4) shows a high correlation between the nutritional level and the frequency of occurrence of a large number of diseases, in particular with respect to pregnant women and infants where the impact of nutritional deficiencies on health is most serious.

The impact of improved nutrition of pregnant women and children on labor productivity will not be felt, of course, until the children reach

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3/ Undernutrition means inadequacy in the quantity of the diet, i.e. in calorie intake, while malnutrition means inadequacy of the nutritional quality of the diet (37, p. 36).

the age where they are expected to participate in the production process. By that time, the under or malnourished child is likely to have had more and/or more severe diseases than the well-nourished child of the same age. Furthermore, the probability that he will not reach that age is considerably higher. In Colombia, 12.6 percent of all children born, die during their first year. Half of these children die from malnutrition (35, p. 244).

Under and malnutrition tends to influence motivation and initiative both by itself and through diseases, hence the performance of the malnourished child in school, if exposed to formal education, is likely to be less than that of the well-nourished child and his value as a production resources is likely to be low.

The impact of under and malnutrition on mental development is another reason why his productivity may be low. Although there is some disagreement among experts, it appears that malnutrition during pregnancy and/or the early period of life may produce irreversable brain damage. Belli (4) reports a number of studies showing a significant correlation between malnutrition and IQ. Pollitt (26) warns us, however, that since malnutrition is usually associated with extreme poverty, it is difficult to separate the impact of malnutrition on intellectual development from the impact of other adverse conditions such as apathy and insufficient learning opportunities.

Although the impact of improved nutrition on health is most serious among infants and young children, it may play an important role among adults. Poor health amont adults due to malnutrition is likely to contribute significantly to a reduction in labor productivity. It

is not clear to what extent this factor is taken into account in the previously mentioned studies on nutrition and labor productivity.

Nutrition and human welfare

According to traditional economic growth theory, improved nutrition would be considered consumption rather than investment and hence nonviable as a factor contributing to self-sustained economic growth (14, p. 5). Improved nutrition was expected to be an outcome of the growth process but was not expected to promote the process. We have now come to believe that improved nutrition does play a role as a promoter of economic growth, particularly in cases of very low nutritional levels. Hence, we may argue that improved nutrition contributes to immediate human welfare through consumption as well as to the welfare of future generations through improvements of the human production resources. We hasten to add that from the point of view of economic growth alone, this argument does not justify including improvement of nutrition as a principal objective of economic growth plans without empirical information on the contribution to economic growth of improved nutrition relative to that of other growth factors. It does, however, in our opinion, justify including improved nutrition in the growth models as a growth factor in its own right.

While it is quite clear from available empirical results that investment in education generally has a high pay-off (29,31), empirical studies are scarce on the pay-off from investment in programs aimed at improving nutrition. Hence, until further information is made available it is probably not advisable to justify investment in nutrition programs exclusively on the basis of its impact on the growth process.

Is the direct impact on human welfare sufficiently important to justify improved nutrition as a major goal in economic development plans? Obviously, improved nutrition and the associated improvements in health would contribute to human welfare. Levinson and Call (14, p. 5) argue that programs to improve nutrition could be justified exclusively on their immediately impact on human welfare when they ask "why not say that by improving the nutritional status of people we are directly improving their health, and hence well-being, in the same way we would by eliminating malaria or smallpox? Without separating growth and welfare objectives, the Commission on International Development (22, p. 62) argues that improved nutrition is indispensable "in order to raise general standards of health, the productivity of labor, and the general quality of life".

Since economic growth is promoted by an expansion in food production and, to some extent, by improved nutrition and since improved nutrition would make a major contribution to welfare, one approach to the problem might be to attempt expanding food production to the point where the nutritional needs were fulfilled, thereby meeting both growth and welfare goals. To be successful, such approach would require extensive public outlays to compensate for the lack of purchasing power among the families short on nutrition. The impact of growth might be considerably greater, were these public funds invested in another growth promoting variable, hence the trade-off between present and future human welfare should be considered. Whether society is willing to forego growth for present welfare would depend to its values with respect to present and future welfare. It might be, of course, that investment in nutrition is the most

growth promoting activity of all. This we will not know until development economists start paying more attention to the problem.

Empirical research on the role of nutrition in the economic development process has been called for by a number of economists. Heady (10, p. 16) calls for more economic analysis on the role of food and its optimal uses in economic development. Myrdal (19, p. 992) argues that "the reason why modern Western economic literature has given little attention to nutrition and levels of living and their relationship to labor input and labor efficiency" ..." can largely be justified by the high income levels attained in the West, combined with social security legislation and other redistributional reforms". It is unfortunate that the economic development models based on Western economic theory and aimed at nations where living standards are low do not take into account nutrition as a growth factor but merely consider it an outcome of the growth process.

We conclude the present discussion by noting that the role of improved nutrition and health as growth factors merits much more research attention than that presently given. Although we know that improved nutrition plays a role both as a growth factor and a welfare factor we do not know the relative contribution of improved nutrition and other growth factors to economic growth. Neither do we know the relative contribution to human welfare of improved nutrition and other activities such as medical programs. Whether improved nutrition should be a principal goal in development plans would depend on the relative contributions to growth and immediate human welfare and the set of values established by society with respect to present vs. future wel-

fare. Certain nations, such as Cuba, have established mass education and health improvements as primary development goals and have allocated relatively large quantities of resources to activities aimed at fulfilling these goals. While the impact on human welfare is clear (11), it is probably too early to evaluate its impact on economic growth.

Alternative means of improving nutrition

Under and malnutrition is basically caused by two factors: (1) insufficient intake of the necessary nutrients and (2) poor utilization of the nutrients by the organism. While both factors may be altered through changes in certain socio-economic variables we may argue that the latter is largely a medical problem (interaction between consumption and health) while the former is primarily a socio-economic problem.

In a free market economy the problem of insufficient intake of the necessary nutrients is caused by demand as well as supply factors. Low consumer incomes, which may be partly due to under and malnutrition, lack of knowledge on nutritional requirements and nutritional values of the various foods available and traditional consumption patterns are the major demand factors causing under and malnutrition. On the supply side we encounter inefficient production methods, high input prices and consequently high production costs. Bringing up consumer incomes to a point where nutritional needs could be fulfilled through the market place would, as already mentioned, require a massive public outlay unless productive employment could be found that would bring minimum incomes up above the subsistance level. On the other hand, the problem of under and malnutrition cannot be solved exclusively on the food supply side. A contri-

bution can be made, however. Adoption of new technology by the agricultural sector is likely to increase production and reduce per unit costs, hence consumption would increase. The impact on nutrition would depend on a number of factors such as the present nutritional level of those who would consume the additional food and the nutritional value of the food.

Efforts to improve nutrition should include (1) making available greater quantities of foods that contain the nutrients in short supply, (2) assure that these additional quantities of nutrients be consumed by under and malnourished people through appropriate distribution, consumer education and expanded incomes of low income consumers either by expanding productive employment or by government subsidies, and (3) provide medical services to assure a high level of utilization of available nutrients by the organism.

Greater quantities of nutrients may be made available in a number of ways. Introduction of new agricultural production technology is likely to expand production and reduce per unit costs of the commodities for which it applies. The impact on nutrition would depend on the magnitude of the expansion, the nutritional value of these commodities and the distribution of the additional quantities on consumer income groups. The impact of new technology on nutrition depends, at least to some extent, on the orientation of the efforts to create and distribute the new technology. Hence, by re-allocating agricultural research and extension resources, the impact on human nutrition may be changed. Breeding for a high lysine maize is a case in point (23). If all resources available for maize breeding had been allocated with the sole objective of increasing yields, i.e. quantity, it is possible that higher yielding

normal maize hybrids or varieties would have been available today than those actually available. On the other hand, if the primary nutritional problem is on of lack of essential amino acids rather than calories, efforts to improve maize protein quality may have considerably more impact on nutrition. Another illustration of how emphasis on improved nutrition might alter the allocation of agricultural research resources relates to the decision concerning relative emphasis on alternative commodities. A research agency faced with the decision whether to allocate research resources to cassava or beans would, if the decision was to be made exclusively to the basis of the impact on nutrition, probably select cassava if the basic nutritional problem were one of calorie shortage and select beans if the problem were one of protein shortage.

We want to emphasize that we are not suggesting that the potential impact on nutrition be the only criteria for allocation of research and extension resources, merely that it be included along with other criteria.

Food quality may be improved through fortification. The socio-economic and nutritional aspects of fortification have been widely discussed elsewhere (9, 14, 27, 34) and will be bypassed in this paper. More high quality food may be made available through development of new products. These products may be based on agriculturally produced raw products such as synthetic foods developed from soybeans (1, 2, 24, 33) or they may be made from other raw materials such as micro-organism (24, 25, 30).

The role of the agricultural sector and government has been mentioned above. In the case of new products we may expect that another sector, private industry, might play a major role in improving nutrition. Berg (6, p. 140) notes that while such opportunity exists, "a reappraisal

of the experience to date suggests that prospects are not bright for reaching a significant number of needy people with proprietary foods marketed in the conventional manner". He sees the main problem as "being the inability of reconciling corporate project with a product low enough in cost to reach the needy in large numbers". As already mentioned, somewhat the same tends to be true with respect to traditional agricultural products.

"Unlike smallpox, malaria and other public health problems, there is no professional consensus on how best to attack malnutrition" (5, p. 16). Attempts have been made to establish minimum cost, adequate diets (5, 21). However, these effots, while interesting, tend to have little practical value due to individual consumer preferences and the impact of expanded demand on product prices.

If improved nutrition is included as a principal goal of development, the strategy to be followed should be determined on the basis of a systems approach, taking into account technical as well as socio-economic factors related to production, distribution (sometimes labelled delivery system), and consumer preferences (23).

The remaining of this paper deals with the nutritional impact of production expansions of traditional foods and how the impact may be altered on the basis of alternative agricultural research priorities. This does not imply that we necessarily believe that expanded production of traditional foods is the most efficient way to improve nutrition. We do feel, however, that too little empirical research has been dedicated to the impact of alternative agricultural research resource allocation on human nutrition and hence we hypothesize that additional quantitative

information might improve the efficiency of the research resource allocation not only from the point of view of nutrition but from the point of view of general human welfare and economic growth.

AN EMPIRICAL ANALYSIS

The empirical analysis reported below forms a part of a larger study presently being carried out by the authors on the expected impact on consumer welfare of expansions of the production of selected foods. Since the study is not yet completed, further analysis and revision may alter the results reported here, hence this report should be considered preliminary.

One of the above mentioned alternative means of improving human nutrition was that related to expanded production of traditional foods. The study reported below attempts to analyze the potential nutritional impact of expanding the supply of each of a number of selected food commodities for a selected population. The impact of expanded food supply at constant consumer incomes is compared to the impact of expanded consumer incomes at constant food prices. The general objective of the study is to analyze the extent to which agricultural production research can be expected to improve human nutrition and to determine how alternative allocations of agricultural production research resources might influence human nutrition.

Present nutritional level

A sample of 230 families was selected from the population of Cali,

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Present nutritional level

A sample of 230 families was selected from the population of Cali,

Colombia, using a stratified random sampling procedure. Data on food consumption, food prices, incomes, family size, age distribution and certain other variables were obtained from these families by means of personal interviews. Each family was visited in February, 1969 by PIMUR (38) and again in August, 1970 by CIAT. The families were divided into five strata according to family incomes (Table 1). Certain characteristics of the families interviewed are shown in Table 1.

Table 2 shows the estimated consumption of selected foods 4/, and Tables 3 and 4 show the estimated calorie and protein intake. As shown in Tables 3 and 4, the two lowest income strata were short on calories, while the three lowest strata were short on protein when compared to the recommended calorie and protein levels 5/. Among the foods included in this analysis, rice and maize were the major sources of calories and protein for the low income strata, while beef was the most important single source of calories and protein for the highest income strata. The eight foods supplied more than one-half of the total calorie intake for four of the five strata and more than two-thirds of the total protein intake for each one of the five strata.

Estimated elasticities

On the basis of the data collected, income elasticities as well as a complete price elasticity matrix were estimated for each strata. Table

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4/ The study includes 22 foods or groups of foods of which eight were selected for the present analysis.

5/ The recommended calorie and protein intake per capita takes into account the age distribution of the families.

5 shows the income elasticities and Tables 6 and 7 show the direct price elasticities and flexibilities. The cross elasticities are not shown, to reduce the volume of data. They were used, however, in the estimations when appropriate. The price elasticities and flexibilities for the various strata were weighted by quantity consumed and population distribution on strata to obtain the coefficients relevant to the total demand.

Estimated impact of supply expansions

Table 8 shows the estimated change in quantity consumed by strata due to a hypothetical 10 percent increase in the supply of each of the eight foods 6/. Assuming perfect competition, one single market price and constant consumer incomes, the change in prices were estimated on the basis of the total demand flexibility. The change in consumption was then estimated for each strata. The impact on per capita consumption of an increasing supply of foods of animal origin would be felt primarily in the high income groups while increases in the production of staple foods such as rice, maize and beans would have the greatest impact on the low income consumer.

The impact of a ten percent supply increase on total calorie and protein intake is shown in Tables 9 and 10. As might be expected, an increase in the production of meats and milk adds very few calories to the diet of the consumers in the calorie deficient strata. The impact of the additional consumption of any one of these foods is reduced by the nega-

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6/ Change in quantity consumed is assumed to be a linear function of the increase in the quantity supplied.

tive impact due to reduced consumption of other foods. In the case of pork, a supply expansion would actually reduce calorie intakes in the lowest strata. A ten percent increase in the supply of beef would increase daily per capita calorie intake in the lowest strata by one calorie while the increase would be 40 calories in the highest strata. Increases in the supply of rice and maize would make a significant contribution to a reduction of the calorie shortage. In the case of protein, the results are somewhat similar, although the contribution of meats and milk to reducing nutritional shortages is slightly better. However, rice and maize are the largest contributors. If the supply of beef is increased 10 percent, the consumer in the lowest income strata adds 0.5 grams of protein to his daily diet while the high income consumer adds 3.2 grams. A ten percent increase in the supply of rice would add one gram of protein to the low income diet and 0.5 grams to the high income diet.

In view of the fact that the quality of protein consumed plays a major role in determining the nutritional level, it was attempted to analyze the impact on the intake of the three essential amino acids, lysine, methionine and tryptophan. It was found, however, that the diets contained more of these amino acids than required at all income levels. Hence, it appears that quantity of protein is more important than quality, for the population studied. A more detailed study of the protein quality aspects of the diets will be performed as part of the overall project.

Table 11 shows two measures of the efficiency of supply expansions to reduce calorie and protein deficiencies. The two measures are (1)

percent of total net addition of calories and protein consumed by deficit groups and (2) reduction in nutrient deficiencies in percent of total deficiency. It was found that approximately one-half of the total net addition of protein, brought about by increasing the supply of livestock products would be consumed by protein deficit groups. If the supply of beef were increased by ten percent, the present protein deficiency would be reduced by eight percent. Supply expansions of pork and milk would make a much smaller contribution: two and 3.5 percent, respectively. Between 80 and 100 percent of the protein from an increased supply of any one of the staple foods would be consumed by protein deficient groups. However, only rice, maize and to a lesser extent, beans would reduce protein deficiencies to any appreciable degree.

The estimated net impact of a ten percent supply increase on total consumer expenditures on food is quite small, particularly among low income consumers (Table 12). A ten percent increase in the supply of beef would decrease total family expenditures on food in strata I by only Col. $0.28/month, once the adjustment in the consumption of other foods have been made. The decrease in total food expenditures of strata V is somewhat larger.

Impact of income increases

Table 13 shows the estimated increase in per capita consumption due to a ten percent increase in consumer incomes assuming constant prices. A ten percent increase in the incomes of low income consumers would result in an expansion of the consumption of meats and milk approximately equal to that caused by a ten percent supply expansion, while the impact on the

consumption of staple foods would be less than that associated with a ten percent supply expansion. Increases in consumer incomes would have a greater impact on per capita calorie intakes in the lower income strata than in the high income strata. The impact on per capita protein intake would be almostequal for all strata (Table 14).

If consumer incomes were increased by 29 percent in the lowest income strata and food prices were kept constant, the calorie requirements would be fulfilled (Table 15). To meet protein requirements in this strata, incomes would need to increase 55 percent. Expressed in monetary terms, family incomes would need to increase from Col.$ 518 to Col.$ 667 to meet calorie requirements and to Col.$ 804 to meet protein needs.

IMPLICATIONS

The average daily per capita intake of calories and protein for the sample as a whole was estimated to be 2,343 and 64.2 grams, respectively, i.e. in excess of requirements. Hence, no additional food would be needed to fulfill calorie and protein requirements if available food were distributed according to needs. This situation clearly points out the inadequacy of average data as a measure of nutritional status.

Although an analysis by economic strata is an improvement over simple average data, we realize that average data by strata fail to reveal differences among families within the strata and among members of any given family. While further analysis of our data will solve the former problem, additional data collection will be needed to study the distribution of food within the family.

Keeping in mind these limitations, the results of this analysis suggest that expanded production of meats and milk without increases in the incomes of low income consumer, either directly through increased employment or indirectly through government intervention, is not likely to reduce calorie and protein deficiencies significantly. If costs of production per unit of product can be reduced sufficiently to compensate for price reductions, an expansion of the production of maize, rice and plantain may provide a considerable amount of calories to the calorie deficit groups. Food supply expansions without increasing consumer incomes are not likely to have any significant impact on protein intake by protein deficient groups. The impact on protein intake of a one percent increase in consumer incomes in strata I, is equal to the impact of an 8 percent increase in beef supply. Likewise, it is equal to a 4 percent increase in rice supply.

It should be noted that it is assumed that food prices remain constant in the case of income expansions. This implies that supply will increase according to income elasticities. Unless supply is perfectly elastic, the introduction of new technology will be needed to shift the supply curve. If income expansions are not followed by shifts in the supply curve, the impact on nutrition is likely to be reduced by increasing food prices. Hence, assuming that consumer incomes do in fact increase, the question from the point of view of nutrition is not whether food production should be expanded but rather the extent to which it should be expanded and which products should be emphasized.

Considering nutritional impact as the only criteria for allocating

agricultural production research resources, the results from the present analysis suggest that, among the eight food considered, major emphasis should be placed on expanding the production of maize, rice, beef and beans in that order.

These priorities take into account the relative impact of supply expansions at constant incomes as well as the supply expansions needed to assure a relatively large nutritional impact of increase in consumer incomes.

Obviously, the nutritional impact is not the only relevant criteria for allocating resources to agricultural production research. The final decision on the allocation of resources should be made on the basis of all relevant criteria. We suggest that the impact on human nutrition be one of these criteria.

Table 1. Certain sample characteristics

	Strata				
Strata	**I**	**II**	**III**	**IV**	**V**
Income range					
Col.$/family/month	0-750	751-1000	1001-2000	2001-3000	3001-up
U.S.$/family/month 1/	0-37.5	37.6-50.0	50.1-100.0	100.1-150.0	150.1-up
Average family income					
Col.$/month	517.54	972.03	1524.10	2600.31	6885.00
U.S.$/month	25.88	48.60	76.21	130.16	344.25
Average per capita income					
Col.$/month	99.79	179.03	263.11	512.36	1176.48
U.S.$/month	4.99	8.95	13.16	25.62	58.82
Expenditures on food					
Col.$/month	86.45	117.30	167.47	255.72	407.89
U.S.$/month	4.32	5.87	8.37	12.79	20.39
Percent of income spent on food	86.6	65.5	63.7	49.9	34.7
Number of families interviewed	46	42	80	32	30
Number of persons in families interviewed	270	264	544	201	200
Distribution of persons on strata (%) 2/	18.3	17.8	36.8	13.6	13.5

1/ The exchange rate used was: U.S.$ 1 = Col.$ 20.00.

2/ Although no exact distribution of the population on income strata is available, the percentage distribution of the sample corresponds with the information available on the population.

Table 2. Daily average consumption of selected foods by strata (grams per capita)

	Strata				
Product	I	II	III	IV	V
Beef	36.60	56.63	82.77	104.96	246.38
Pork	9.63	19.12	21.02	48.18	75.21
Milk	44.33	69.76	131.77	238.38	410.63
Rice	83.44	90.46	90.86	104.89	87.53
Maize	83.60	95.44	97.24	36.70	37.02
Beans	19.00	24.51	24.63	26.66	30.50
Potatoes	74.10	84.84	72.44	80.48	95.11
Plantain	108.45	139.22	126.00	70.83	59.92

Table 3. Daily per capita calorie intake from selected foods, by strata

Product	Calorie content per kilo 1/	Strata I	II	III	IV	V
Beef	2320	52.43	89.01	145.93	208.82	550.17
Pork	2480	18.87	39.24	48.61	108.73	169.74
Milk	600	26.60	41.86	79.06	143.03	246.38
Rice	3590	299.55	324.75	326.19	376.58	314.23
Maize	3220	269.19	307.32	313.11	118.17	119.20
Beans	3020	57.38	74.02	74.38	80.51	92.11
Potatoes	910	67.43	77.20	65.92	73.24	86.55
Plantain	1420	154.00	197.69	178.92	100.58	85.09
Other foods	-	862.06	804.87	1091.27	1373.99	1727.21
Total intake	-	1807.51	1955.96	2323.39	2583.65	3390.68
Recommended intake 2/	-	2150.00	2150.00	2150.00	2150.00	2150.00
Calorie balance	-	-342.49	-194.04	173.39	433.65	1240.68

1/ Instituto Nacional de Nutrición - Tabla de contenido de proteínas y calorías.

2/ Roberto Rueda - Williamson, et. al. Recomendaciones de Consumo de Alimentos para Colombia, 1969. Instituto Colombiano de Bienestar Familiar, INV-69-05, p. 7.

Table 4. Daily per capita protein intake from selected foods, by strata

Product	Protein content per kilo of product 1/ (grams)	Strata I	II	III	IV	V
Beef	187	4.23	7.18	11.77	16.84	44.35
Pork	165	1.25	2.61	3.24	7.24	11.29
Milk	34	1.51	2.37	4.48	8.10	13.96
Rice	78	6.51	7.06	7.09	8.18	6.83
Maize	80	6.69	7.64	7.78	2.94	2.96
Beans	200	3.80	4.90	4.93	5.33	6.10
Potatoes	19	1.41	1.61	1.38	1.53	1.81
Plantain	12	1.30	1.67	1.51	0.85	0.72
Other foods	-	14.50	11.64	17.23	24.69	31.73
Total intake	-	41.20	46.68	59.41	75.70	119.75
Recommended intake 2/	-	62.00	62.00	62.00	62.00	62.00
Protein balance	-	-20.80	-15.32	-4.69	13.60	57.65

1/ Instituto Nacional de Nutrición - Tabla de contenido de proteínas y calorías.

2/ Roberto Rueda - Williamson, et. al. Recomendaciones de Consumo de Alimentos para Colombia, 1969. Instituto Colombiano de Bienestar Familiar, INV-69-05, p. 7.

Table 5. Estimated income elasticities for selected foods, by strata

	Strata				
Product	I	II	III	IV	V
Beef	1.5206	1.3525	0.9926	0.6706	0.4732
Pork	1.9440	1.6469	1.1230	0.8179	0.6921
Milk	1.8329	1.6499	1.1265	0.6328	0.1977
Rice	0.4070	0.3875	0.3880	0.2753	0.1860
Maize	0.6198	0.5408	0.4353	-0.2615	-0.4259
Beans	0.8048	0.7730	0.6440	0.4500	0.2500
Potatoes	0.4010	0.4108	0.3082	-0.3000	-0.3100
Plantain	0.5184	0.4774	0.3889	-0.3139	-0.2914

Table 6. Estimated direct price elasticities by strata and weighted average for the population of Cali

	Strata					
Product	I	II	III	IV	V	Weighted average
Beef	-1.5557	-1.2827	-0.9908	-1.0610	-0.7814	-0.9987
Pork	-2.0565	-1.5794	-1.1153	-1.2897	-1.1243	-1.2663
Milk	-1.9485	-1.5912	-1.1177	-1.0051	-0.3246	-0.8943
Rice	-0.6173	-0.5560	-0.5741	-0.2912	-0.3085	-0.4988
Maize	-0.6862	-0.5325	-0.4396	0.4170	0.7387	-0.3778
Beans	-0.8626	-0.7436	-0.5217	-0.4167	-0.1633	-0.5336
Potatoes	-0.4010	-0.3466	-0.2500	-0.1810	-0.1538	-0.2685
Plantain	-0.5768	-0.4784	-0.3938	0.5021	0.4755	-0.3023

Table 7. Estimated direct price flexibilities by strata and weighted average for the population of Cali

	Strata					
Product	I	II	III	IV	V	Weighted average
Beef	-0.6445	-0.7785	-1.0092	-0.9451	-1.2675	-0.9943
Pork	-0.4874	-0.6327	-0.8965	-0.8171	-0.8907	-0.7893
Milk	-0.5143	-0.6281	-0.8946	-0.9950	-3.0637	-1.1135
Rice	-1.6129	-1.7979	-1.7414	-3.4025	-3.2352	-1.9943
Maize	-1.4548	-1.8777	-2.2744	2.3905	1.3522	-2.6456
Beans	-1.1586	-1.3448	-1.9166	-2.3927	-6.1018	-1.8758
Potatoes	-2.4861	-2.8845	-3.9991	-5.6173	-6.5590	-3.7012
Plantain	-1.7301	-2.0898	-2.5386	1.9810	2.0996	-3.3134

Table 8. Distribution of a ten percent supply increase of selected foods on strata

Product	% change in price	Change in consumption by strata I %	I Grams/ cap/day	II %	II Grams/ cap/day	III %	III Grams/ cap/day	IV %	IV Grams/ cap/day	V %	V Grams/ cap/day
Beef	- 9.943	15.5	5.66	12.8	7.22	9.9	8.16	10.6	11.07	7.1	17.60
Pork	- 7.893	16.2	1.56	12.5	2.38	8.8	1.85	10.2	4.91	8.9	6.67
Milk	-11.135	21.7	9.62	17.7	12.36	12.4	16.40	11.2	27.68	3.6	14.84
Rice	-19.943	12.3	10.27	11.1	10.03	11.4	10.40	5.8	6.09	6.2	5.39
Maize	-26.456	18.2	15.18	14.1	13.45	11.6	11.31	-11.0	- 4.05	-19.5	- 7.24
Beans	-18.758	16.2	3.07	13.9	3.42	9.8	2.41	7.8	2.08	3.1	0.93
Potato	-37.012	14.8	11.00	12.8	10.88	9.3	6.70	6.7	5.39	5.7	5.41
Plantain	-33.134	19.1	20.73	15.9	22.07	13.0	16.44	-16.6	-11.78	-15.8	-9.44

:t of a ten percent supply increase on calorie intake by strata

(calorie per capita per day)

Strata											
II			III			IV			V		
Indir.	Net impact	Direct	Indir.	Net impact	Direct	Indir.	Net impact	Direct	Indir.	Net impact
-3.749	7.603	14.378	0.184	14.562	23.639	-0.438	23.201	39.298	1.033	40.331
-2.132	2.759	4.280	-0.391	3.889	11.069	-0.700	10.369	15.062	-0.181	14.881
-2.155	5.202	9.840	-0.669	9.171	16.607	-0.029	16.578	8.904	1.008	9.912
6.955	42.963	37.347	5.200	42.547	21.867	2.039	23.906	19.332	0.754	20.086
4.043	47.339	36.415	4.035	40.450	-13.038	1.497	-11.541	-23.297	0.628	-22.669
1.681	12.006	7.278	1.921	9.199	6.294	0.556	6.850	2.821	0.473	3.294
7.061	16.965	6.100	5.707	11.807	4.906	4.690	9.596	4.927	1.976	6.903
6.900	38.287	23.345	6.447	29.792	-16.733	1.752	-14.981	-13.405	0.981	-12.424

in the consumption of the product in question.

in the consumption of other foods.

ct of a ten percent supply increase on protein intake, by strata

(grams per capita per day)

Strata										
II			III			IV			V	
Indir.	Net impact	Direct	Indir.	Net impact	Direct	Indir.	Net impact	Direct	Indir.	Net impact
-0.098	0.818	1.160	0.003	1.163	1.905	-0.015	1.890	3.167	0.045	3.212
-0.063	0.262	0.285	-0.011	0.274	0.736	-0.028	0.708	1.002	0.009	0.993
-0.066	0.354	0.558	-0.019	0.539	0.941	-0.000	0.941	0.505	0.057	0.562
0.231	1.013	0.811	0.173	0.984	0.475	0.095	0.570	0.420	0.043	0.463
0.129	1.205	0.905	0.131	1.036	-0.324	0.063	-0.261	-0.579	0.033	-0.546
0.048	0.732	0.482	0.058	0.540	0.417	0.023	0.440	0.187	0.025	0.212
0.222	0.429	0.127	0.182	0.309	0.102	0.207	0.309	0.103	0.106	0.209
0.228	0.493	0.197	0.214	0.411	-0.141	0.138	-0.003	-0.130	0.052	-0.078

n the consumption of the product in question.

n the consumption of other foods.

Table 11. Impact of a ten percent supply increase on calorie and protein deficiencies

Product	Percent of calories and protein consumed by deficient groups		Reduction in nutrient deficiencies in percent of total deficiency	
	Calories	Protein	Calories	Protein
Beef	10.12	48.74	1.62	7.96
Pork	8.96	42.22	0.49	2.04
Milk	15.70	59.67	1.34	3.65
Rice	42.65	84.09	16.55	8.83
Maize	63.84	100.00 1/	18.62	10.17
Beans	45.95	83.48	5.08	5.42
Potatoes	49.87	79.85	6.74	3.37
Plantain	65.15	100.00 1/	13.94	3.95

1/ Since the direct price elasticities for maize and plantain is positive for the high income strata, the increase in the quantity consumed by low income strata exceeds the increase in supply.

Table 12. The impact of a ten percent supply increase on total food expenditures, by strata

Product	Strata I		Strata II		Strata III		Strata IV		Strata V	
	Change in total expenditures on food 1/	Change in % of total expenditures on the particular food	Change in total expenditures on food 1/	Change in % of total expenditures on the particular food	Change in total expenditures on food 1/	Change in % of total expenditures on the particular food	Change in total expenditures on food 1/	Change in % of total expenditures on the particular food	Change in total expenditures on food 1/	Change in % of total expenditures on the particular food
Beef	-0.28	-0.43	-0.09	-0.08	-2.26	-0.98	-1.68	-0.64	-1.46	-1.68
Pork	0.02	0.08	0.32	0.73	-0.14	-0.23	1.26	0.94	0.48	0.20
Milk	-0.91	-4.95	0.13	0.41	-0.57	-0.76	-1.58	-1.21	-15.08	-8.88
Rice	-0.63	-1.30	-1.96	-3.28	-3.20	-4.63	-9.78	-12.20	-9.11	-13.17
Maize	-1.93	-6.83	-2.92	-8.19	-4.51	-10.28	-1.09	-6.90	-5.53	-35.06
Beans	-1.02	-3.72	-1.70	-4.62	-3.18	-7.40	-4.82	-10.99	-7.59	-14.79
Potatoes	-2.53	-10.51	-4.63	-14.83	-5.87	-17.84	-5.82	-17.59	-10.57	-26.11
Plantain	-2.09	-7.21	-4.58	-11.34	-6.94	-14.07	-9.42	-31.96	-8.61	-37.34

1/ (Col.$/family/month).

Table 13. The impact of a ten percent increase in consumer incomes on consumption, by strata

	Strata									
	I		II		III		IV		V	
Product	%	Grams/ cap/day	%	Grams/ cap/day	%	Grams/ cap/day	%	Grams/ cap/day	%	Grams/ cap/day
Beef	15.2	5.57	13.5	7.50	9.9	8.22	6.7	7.04	4.7	11.66
Pork	19.4	1.87	16.5	3.14	11.2	2.36	8.2	3.94	6.9	5.21
Milk	18.3	8.13	16.5	11.51	11.3	14.84	6.3	14.87	2.0	8.12
Rice	4.1	3.40	3.9	3.51	3.9	3.53	2.8	2.89	1.9	1.63
Maize	6.2	7.69	5.4	5.16	4.4	4.23	-2.6	-0.96	-4.3	-1.58
Beans	8.1	1.53	7.7	1.90	6.4	1.59	4.5	1.20	2.5	0.76
Potatoes	4.0	2.97	4.1	3.49	3.1	2.23	-3.0	-2.41	-3.1	-2.95
Plantain	5.2	5.62	4.8	6.65	3.9	4.90	-3.1	-2.22	-2.9	-1.75

Table 14. The impact of a ten percent increase in consumer incomes on calorie and protein intake, by strata

	I		II		III		IV		V	
Product	Calories[1]	Protein[2]	Calories	Protein	Calories	Protein	Calories	Protein	Calories	Protein
Beef	7.972	0.643	12.039	0.971	14.485	1.168	14.003	1.129	26.034	2.099
Pork	3.669	0.243	6.458	0.430	5.459	0.364	8.894	0.592	11.748	0.781
Milk	4.875	0.276	6.906	0.391	8.906	0.505	8.922	0.506	4.871	0.276
Rice	12.192	0.265	12.584	0.273	12.656	0.275	10.367	0.225	5.845	0.127
Maize	16.685	0.615	16.620	0.413	13.630	0.339	-3.090	-0.077	-5.077	-0.126
Beans	4.618	0.306	5.722	0.379	4.790	0.317	3.607	0.240	2.303	0.153
Potatoes	2.704	0.051	3.172	0.066	2.032	0.042	-2.197	-0.046	-2.683	-0.056
Plantain	7.983	0.067	9.438	0.080	6.958	0.059	-3.157	-0.027	-2.479	-0.021
Others	57.882	1.293	53.078	0.985	60.756	1.131	46.579	0.976	29.736	0.844
Total	118.580	3.759	126.017	3.988	129.672	4.200	83.928	3.518	70.298	4.077

1/ Calories per capita per day.

2/ Grams per capita per day.

Table 15. Increase in consumer incomes needed to fulfill nutritional requirements, by strata

	Strata		
Calories	I	II	III
Increase in per capita incomes (%)	28.88	15.40	-
Increase in per capita incomes (Col.$)	28.82	27.57	-
Increase in incomes per family (Col.$)	149.48	149.67	-
Increase in incomes per family (U.S.$)	7.47	7.48	-
Protein			
Increase in per capita incomes (%)	55.33	38.42	11.17
Increase in per capita incomes (Col.$)	55.22	68.77	29.38
Increase in incomes per family (Col.$)	286.41	373.41	170.20
Increase in incomes per family (U.S.$)	14.32	18.67	8.51

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