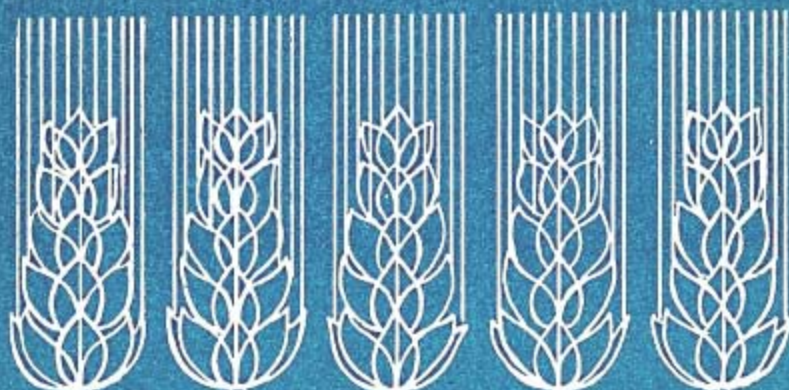


ARCHIVOS
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CONTINUACION DE
ARCHIVOS VENEZOLANOS DE NUTRICION



ORGANO OFICIAL DE LA SOCIEDAD
LATINOAMERICANA DE NUTRICION

VOL. XXVI

JUNIO 1976

N° 2

Archivos Latinoamericanos de Nutrición (ALAN) es editado como órgano oficial de la Sociedad Latinoamericana de Nutrición (SLAN), para la divulgación de conocimientos en el campo de la alimentación y de la nutrición, principalmente en el hemisferio americano. En sus páginas se acogerán manuscritos en español, inglés, portugués y francés, tanto de miembros como de aquellos que no sean miembros de la Sociedad, y de cualquiera de las siguientes categorías: 1. Trabajos generales (revisiones científicas críticas); 2. Trabajos de investigación (originales); 3. Trabajos de Nutrición Aplicada (resultados analíticos de programas de intervención y discusión de recomendaciones de aplicación práctica); y 4. Cartas al Editor (comentarios cortos de interés general o relacionados con resultados o conceptos científicos publicados previamente en Archivos).

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Archivos Latinoamericanos de Nutrición (ALAN) is the official publication of the Sociedad Latinoamericana de Nutrición (SLAN), for the dissemination of knowledge in the fields of food and nutrition principally throughout the American Hemisphere. It accepts articles in Spanish, English, Portuguese and French, both from the society members and from non-members, in the following categories: 1. General Papers (critical scientific reviews); 2. Research Papers (original); 3. Papers in Applied Nutrition (analytical results from intervention programs and discussions of recommendations of practical application); and 4. Letters to the Editor (short comments of general interest or about scientific facts and concepts previously published in the Archivos).

The subscription is US \$ 12.00 per yearly volume (4 numbers) including mail.

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Instituto Nacional de Nutrición de Venezuela
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Dirección: Archivos Latinoamericanos de Nutrición
Apartado 2049
Caracas, Venezuela

Arch. Latinoamer. Nutr.

ALAN-VE ISSN 0004-0622

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ARCHIVOS LATINOAMERICANOS DE NUTRICION

ORGANO OFICIAL DE LA
SOCIEDAD LATINOAMERICANA DE NUTRICION

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ARTICULOS GENERALES

PROTEIN-CALORIE SUPPLEMENTATION AND
POSTNATAL PHYSICAL GROWTH: A REVIEW OF
FINDINGS FROM DEVELOPING COUNTRIES ¹

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SUMMARY

The literature on the effects of protein-calorie supplementation on physical growth rates in height and weight is reviewed. Only studies carried out in moderately malnourished children from developing nations are considered. Two main questions are asked: 1) Do changes in protein-calorie intake cause changes in growth in these children, and 2) How does the impact on growth of supplemental foods vary with changing protein-calorie amounts of the supplement and of the home diet? Although, the experiments reviewed were shown to have a series of limitations, it was concluded that protein-calorie supplementation is causally related to growth. Moreover, the evidence reviewed suggests that the relative contribution of calories and proteins to the association depends upon which nutrient is limiting in the home diet. That is, if proteins are limiting, proteins and not calories are apparently beneficial for growth rates. On the other hand, if calories are limiting, calories alone seem to improve growth rates. This suggests that before expensive supplementation programs are instituted, one should first investigate which nutrients are most limiting in the home diet.

1. This research was supported by Contract NO1-HD-5-0640 from the National Institute of Child Health and Human Development, National Institutes of Health, Bethesda, Maryland, U.S.A.
2. From the Division of Human Development, Institute of Nutrition of Central America and Panama.
3. Head of the above-mentioned Division.
INCAP Publication I-830.

Recibido: 6-11-1975.

INTRODUCTION

Protein-calorie malnutrition (PCM) is the major nutritional problem in children of developing nations. While severe forms of PCM (kwashiorkor and marasmus) affect less than 3% of all children 1 to 5 years of age, mild and moderate forms affect a larger number, around 75%¹.

Because the most common manifestation of mild-to-moderate PCM is physical growth retardation, most of the indicators proposed to evaluate the impact of public health programs are based upon physical growth². However, while the sensitivity of physical growth to nutritional improvements may be easily demonstrated under rigidly controlled situations as in metabolic wards, it is not clear that such would be the case under field conditions. The problems of measurement as we shall see, vastly complicate any such field study. Consequently, considering the importance of this problem, the present paper reviews the literature on field protein-calorie supplementation experiments and their effects on physical growth in height and weight of mild-to-moderately malnourished children. Two main questions guide the literature review.

- A. Do changes in protein-calorie intake cause changes in the growth of mild-to-moderately malnourished children?
- B. How does the impact on physical growth of supplemental foods vary with changing protein-calorie amounts of the supplement and of the home diet?

Our focus on only height and weight as physical growth indicators stems from the fact that these are overall indicators of growth widely used in public health to assess nutritional status². In particular, most food supplementation experiments include at least these measurements. They are therefore, a common denominator by which the various experiments can be compared.

METHODS

More emphasis will be devoted to those studies which provide data regarding the protein and the calorie amounts ingested per day from the supplement and the home diet. Our summary will touch on all the following aspects:

1. The study design: number and age of subjects, dietary intake, nature of control groups and duration of the experiment.

2. The food supplement: its characteristics, the degree to which it replaces home dietary intake, its distribution and measurement.
3. The findings: the impact observed on growth and the conclusions reached.

The main characteristics of the studies reviewed are presented in Table 1.

RESULTS

A. *Have Previous Studies Shown that Changes in Protein and Calorie Intake Cause Changes in the Growth of Mild-to-Moderately Malnourished Children?*

By 4 to 5 years of age almost all mild-to-moderately malnourished children are smaller and lighter than almost any child from the developed nations (i.e. the population distribution overlaps less than 3%). These growth differences are usually attributed to environmental factors, principally low dietary intakes and high morbidity rates. In other words, this stunting does not seem to be attributable to genetic factors^{3, 4}. It follows, therefore, that bettering the nutrition of these children should result in faster growth.

The literature on this subject is, in general, in agreement with this hypothesis. Except for a minority of studies^{5, 6}, most previous experiments, according to their respective authors, are suggestive of an effect of proteins, calories or both⁷⁻¹⁸. However, in evaluating each of the studies, a whole series of limitations which potentially may invalidate the conclusions can be identified. The general nature of these is discussed below.

Measurement of the treatment

There are problems related to the reliability with which the independent variable, supplement intake, was measured. In some instances, the supplements were distributed indirectly in weekly supplies to the family^{5, 6}. Under these circumstances, one does not easily know how much of the supplement each child really took. In most studies, however, the supplements were given directly to the children in a fixed locale⁷⁻¹⁸. Still, some children may attend more frequently and/or eat more than others. Moreover, if the supplements given to various test

groups differ in terms of factors which may make them less or more attractive such as palatability or prestige, not only individuals but groups as a whole may markedly depart from what one thinks they consumed. Therefore, one needs to measure, for both test and control subjects, not only attendance but intake at the individual level as well.

While this was done by a few studies ^{8, 13}, the information with regard to individual variability was not taken into account in the analyses. Lastly, none of the studies reported on another important aspect: the reliability with which the actual intake of individuals was measured.

Poor reliability takes away power, so that differences between control and test groups may appear to be less certain than they really are in some instances; otherwise true differences may not be statistically significant. In this case, the absence of a finding need not necessarily mean that there was no effect; it simply says that the study lacked the power to establish whether or not an association exists.

It is interesting to note in this regard that the studies here reviewed, where the treatment was given in weekly supplies to the mother, where the poorest reliability would be expected, were the only ones not showing significant differences between test and control subjects ^{5, 6}.

Replacement

Related to the problem of measurement of the independent variable is the whole issue of the supplements replacing dietary intake at the home. Some of the studies reviewed here did not measure replacement rates ^{5, 6, 9, 10, 16, 17}. Some studies, on the other hand, faced this issue by relying on single dietary surveys in test and control subjects ¹⁸ or on single dietary surveys on test groups before and during the experiment ^{8, 13}. Since the reliability of individual dietary surveys is low ¹⁹, either large numbers of subjects or more frequent surveys in a small number of subjects are required to have sufficient power to evaluate the extent of replacement. For example, assuming a standard deviation of 300 calories, it would take a sample of 140 in each of the groups to show at a power of 0.80, that the mean dietary intake of calories of test and control subjects differ significantly ($p < .05$) by 100 calories ²⁰. It is not surprising therefore, that in all studies where this problem was investigated,

the home dietary intake of test and control groups did not differ significantly ^{8, 13, 18}.

If replacement of the home diet by the supplement does occur, the dose response in terms of growth per calorie or gram of protein given in the supplement will be underestimated. To correct for replacement, one would have to relate the amount of calories actually ingested above the baseline intake with growth.

Replacement may bring about a second kind of problem. In cases where the preparations given to test and control groups differ in terms of their attractiveness or bulk, there may be varying rates of replacement across experimental groups. Such an occurrence may introduce sources of bias which may lead to erroneous conclusions.

Measurement of growth

If the equipment is calibrated and the anthropometrist is adequately trained, measurement of the dependent variable, growth, probably presents no problems given the high reliability of anthropometric measurements, particularly of height and weight ²¹. When dealing with incremental, as opposed to attained values, measurement error increases given that error may occur at both end points, beginning and end. How "large" this error is depends upon the ratio of the error variance to the population variance in incremental growth ²¹. None of the studies reviewed presented the necessary data to assess these aspects.

Alternative hypothesis

Ideally, a food supplementation experiment should have at least two characteristics. Subjects should be randomly assigned to test and control groups. Secondly, the experimenter should set the amount of treatment to be ingested by each group at a specified frequency. All of this, however, is very difficult to do with human populations because of ethical and operational constraints. Most studies therefore depend upon the willingness of subjects to participate. This of course raises the possibility that the findings observed are due to factors other than the treatment given.

Not surprisingly, most studies drew control and test groups from already existing groups: attenders and non attenders to a preschool ¹⁰, separate villages ^{6, 8, 9, 18}, separate health care cen-

ters⁵, separate classes within a school¹² or separate schools^{7, 11}. Within these groups, in some studies the test subjects were those willing or permitted to participate rather than all members of the group^{10, 18}.

Moreover, none of the above studies^{5-12, 18} report either what percentage of the group intended for study remained in the study, or what characteristics those not studied had with respect to those studied. In general, very little effort, other than comparing test and control subjects in terms of initial height, weight and age was done to assure comparability of the experimental groups. Therefore, these studies^{5-12, 18} did not control either through their designs or data collection, for possible differences in factors which may affect growth and which potentially may explain the findings such as morbidity⁽⁴⁾, socio-economic status and home dietary intake as well.

A minority of studies carried out in orphanages randomly allotted subjects to test and control groups from matched pairs on the basis of initial height and weight^{16, 17}. These studies, however, did not control for actual intake; thus, the bulkier control diet may have been consumed in lesser amounts than the high-protein diet (see Table 1).

In conclusion, the evidence reviewed suggests that protein-calorie nutrition is at least related to changes in growth. Though there may be strong reasons to doubt the conclusions of individual studies, when all these experiments are viewed in total, negating the hypothesis that protein-calorie nutrition affects growth may require that the same source of bias act similarly across all studies. This is very improbable as is the possibility that a very complicated combination of biases act in each of the reviewed studies.

B. *How Does the Impact on Physical Growth of Supplemental Foods Vary with Changing Protein-Calorie Compositions of the Supplement and of the Home Diet?*

The issue to be dealt with is that proteins, calories or both will have an impact on physical growth depending upon which nutrient is limiting in the home dietary intake. In this respect,

(4) Gopalan *et al.*⁸ report that there was a measles epidemic during the study which was associated with reduced growth in the control but not in the experimental subjects. However, differences between control and experimental groups, given the presence or absence of measles, were still evident.

TABLE 1 - MAIN CHARACTERISTICS OF SOME PROTEIN-CALORIE SUPPLEMENTATION STUDIES

REFERENCE AND POPULATION	DIETARY INTAKE	PROTEIN-CALORIE CONTENT OF TREATMENT. (SAMPLE SIZE IN PARENTHESIS).	DISTRIBUTION AND MEASUREMENT OF SUPPLEMENT INTAKE	FINDINGS
Bancraft & Bailey (5) New Guinea. Infant 6-12 months of age. Study lasted 12 months	Staple is sweet potato. Breast milk intake is 600 cc (320 cal & 5g protein). Author estimates total intake to be 300-1000 cal (40.5-135.1 cal/kg) and 5-10g protein per day (0.7-1.4g/kg) Protein-calorie deficient.	Groups drawn from health care clinics Cal. Prot. 1. (13) 101 10.1 (skimmed milk) 2. (19) 284 11.4 (peanut butter) 3. (16) 134 9.8 (soya bean meal) 4. (18) -- -- (control) 5. (15) -- -- (control)	- Weekly supplies delivered or picked up by parents. - Direct consumption not verified - Cases whose mother missed 15 or more weeks excluded	Yearly increments ($\bar{X} \pm S.E.$) Weight (kg) Height (cm) 1. 2.16 \pm .18 11.3 \pm .75 2. 2.39 \pm .13 11.4 \pm .30 3. 2.46 \pm .23 11.0 \pm .61 4. 2.30 \pm .11 11.0 \pm .41 5. 2.24 \pm .18 11.5 \pm .54 No effect of protein-calorie supplementation. Growth increments of all groups fairly similar to those of well-nourished populations.
Baertl et al (6) Perú. Children 0.5 to 18 years of age. 6 year study	Not Detailed	Four populations with large sample size: 1. Control 2. Control 3. 250 cal and 7.5g/day (wheat noodles) 4. 250 cal and 12.5g/day (wheat noodles with fish protein)	- Indirectly to mothers - Intake not reported - Replacement not reported	Results suggest that protein-calorie supplementation did not influence growth.
Bailey (7) Indonesia Children 7 to 13 years of age. 12 months study	Mostly cassava. 1006 cal (44cal/kg) and 9.8 g of protein per day (0.4g/kg). Protein-calorie deficient	7 Groups drawn from 3 schools Cal. Prot. 1. (66) 0 0 (iron-control) 2. (75) 180 1.5 (sugar) 3. (74) 195 12 (green gram + sugar) 4. (71) 90 10 (skimmed milk) 5. (74) 170 10 (soya bean milk) 6. (73) 80 12.5 (soya) 7. (71) 50 10 (velvet bean)	- Control, on school days - Intake not reported - Replacement not reported	No clear significant effect is produced by any of the treatments but there is a tendency for gains in height and weight to be correlated with the caloric value of the supplements (Spearman respectively 0.86 and 0.75, $p < .01$)
Gopalan et al (8) India. Children 1 to 5 years of age. 14 months study.	700 cal and 18.5g per day. 1.1 gm ref. protein/kg. Mainly calorie deficient.	Two groups drawn from 9 villages. Not clear how chosen. Controls matched for age, sex, height and weight. Cal. Prot. 1. (109) 310 3 (wheat + sugar + oil) 2. (306) -- -- (control)	- Control, 6 days/week - 85% attendance - Intake not reported - Dietary surveys before and during experiment (n/40) reveal no replacement)	14 months increments Age Weight (kg) Height (cm) Exp Control Exp Control 1-2 2.35 1.74 9.3 8.5 2-3 2.34 1.71 9.5 7.8 3-4 2.04 1.58 9.1 7.4 4-5 1.86 1.38 8.4 7.3 All comparisons highly significant. Suggests a caloric effect.

TABLE 1 - (CONT'D)

REFERENCE AND POPULATION	DIETARY INTAKE	PROTEIN-CALORIE CONTENT OF TREATMENT. (SAMPLE SIZE IN PARENTHESIS)	DISTRIBUTION AND MEASUREMENT OF SUPPLEMENT INTAKE	FINDINGS
Guzman et al (9); Some data drawn from (14,15), Guatemala. Children 0 to 5 years of age. 5 year study.	687 cal and 19.2 g protein/day in children (0-4 years) of feeding village. Approx. 68.7 cal and 1.92 g protein per kg per day. Mainly calorie deficient.	3 villages: control, medical care, and feeding village. Large samples. Treatment approx. 15 g protein and 350 cal/day (Incaparina, skim milk, sugar, banana)	- Central, 6 days/week - Ad libitum, variability in intake not taken into account - Replacement not reported	More rapid growth in both height and weight for children of feeding village. Relative to the 2 other villages the treatment resulted in a net diff. of 3 cm in height and 1 kg of weight by 5 years of age. Results suggest a protein-calorie effect.
Kamatharajan et al (10) India. Children 2.5 to 5 years of age. 6 months study	Home diet of control group: 486 cal (49.6 cal/kg) and 13.7g protein per day (1.4 g/kg). Mainly calorie deficient.	Experimental Group (25) Cal. Prot. Treatment 898 26.4 Home diet 283 8.9 Total 1181 35.4 Supplement: mixture of sesame, groundnut and horsegram. Controls were other village children not willing or permitted to participate	- Central - Frequency not stated - Intake not reported - Treatment meant to partly replace dietary intake	Semestra Increments (S) Weight (kg) Height (cm) Exp 2.23 --- 2.71 Control 1.23 --- 1.94 p / .01 p / .01 Only 15 children of the experimental group were included for analysis; these were of similar initial heights and weights as control children. Results suggest a protein-calorie effect.
Ning et al (11) Haiti. Children 4 to 18 years of age. Study lasted 261 days	Based on a previous study, the per capita intake is estimated at 1580 cal and 37g of protein per day. This includes subjects of all ages.	Three groups, each a separate school Cal. Prot. 1, (223) 391 12.7 (enriched bread and jelly) 2, (145) 391 13.4 (same but with lysine) 3, (111) -- -- (control)	- Central, 150 feeding days. - Intake not reported - Replacement not reported	Groups 1 and 2 show better growth than 3 particularly in weight growth. This is suggestive of a protein-calorie effect. There is a fairly constant tendency throughout the age range for group 2 to show better growth than group 1. This suggests that protein quality may also be related to growth.
Malcolm (12) New Guinea. Children 6 to 16 years of age. 13 week study.	Staples are taro and sweet potato. 1610 cal (73.2cal/kg) and 12g protein per day (0.5g/kg). Protein deficient.	Groups drawn from different classes within a school. Cal. Prot. 1, (31) 270 25 (skim milk) 2, (22) 270 -- (margarine) 3, (22) 660 5 (2 extra meals of basic diet) 4, (35) -- -- (control)	- Central, 5 days/week - Intake not reported - Replacement not reported. Author suspects replacement in Group 3.	13 week increments ($\bar{X} \pm S. E.$) Weight (kg) Height (cm) 1. 1.21 \pm .10 2.32 \pm .11 2. 1.05 \pm .18 0.96 \pm .11 3. 0.47 \pm .14 1.54 \pm .13 4. 0.50 \pm .13 1.10 \pm .12 Height and weight of protein-calorie group is best. Calories affect weight but not height growth. Height of group 3 better than that of groups 2 and 4 possibly due to extra protein. Study suggests a protein effect.

TABLE 1 - (CONT'D)

REFERENCE AND POPULATION	DIETARY INTAKE	PROTEIN-CALORIE CONTENT OF TREATMENT. (SAMPLE SIZE IN PARENTHESIS)	DISTRIBUTION AND MEASUREMENT OF SUPPLEMENT INTAKE	FINDINGS
Rajalakshmi et al (13) India. Children 2 to 6 years of age. 6 month study	900 cal (75cal/kg) and 23g of protein per day (1.92g/kg) Calorie deficient	Groups drawn from a rural clay center Controls matched for age, height and weight. Cal. Prot. 1. (11) 185 6.7 (wheat + Bengal gram) 2. (13) 245 9.2 (the above + greens) 3. (10) 320 11.8 (all of the above + lime) 4. (9) --- --- (control)	- Central - Ad libitum. Individual records kept. Intakes reported are group means. - No differences between and within groups in home dietary intake.	Six months increments ($\bar{X} \pm S.E.$) Weight (kg) Height (cm) 1. 1.1 \pm .09** 3.0 \pm .24* 2. 1.2 \pm .12** 3.1 \pm .11** 3. 1.5 \pm .08** 3.2 \pm .30** 4. 0.2 \pm .01 2.0 \pm .17 T-test vs control: * p \leq .05, ** p \leq .01. Results suggest a protein-calorie effect
Subramanyan et al (16) India Girls 4 to 11 years of age. 6 month experiment	Baseline data not reported. Likely to be similar to that of reference (17)	Groups drawn from an orphanage. Random assignment to groups from matched pairs on the basis of initial height and weight. Cal. Prot. 1. (21) 1311 35.4 (groundnut, sugar, milk) 2. (21) 1311 25.2 (diet isocaloric by means of corn starch and sugar).	- Central, daily - Intake not reported - Replacement not reported	Six month increments (\bar{X}) Weight (kg) Height (cm) 1. 1.16 2.42 2. 0.58 1.59 Diff: p \leq .01 p \leq .01 Results suggest a protein effect
Subramanyan et al (17) India. Girls 4 to 12 years of age. 5 month study.	970 cal (51.3 cal/kg) and 24.4 g of protein/day (1.2g/kg). Mainly calorie deficient	Groups drawn from an orphanage. Random assignment to groups from matched pairs on the basis of initial height and weight. Cal. Prot. 1. (23) 220 20.6 (groundnut, Bengal gram, vitamins and calcium) 2. (23) 220 --- (maize starch and sugar)	- Central, daily - Intake not reported - Replacement not reported	Five month increments (\bar{X}) Weight (kg) Height (cm) 1. 1.16 2.42 2. 0.45 1.31 Diff: p \leq .01 p \leq .01 Results suggest a protein effect
Swaminathan et al (18) India. Children 1 to 5 years of age. 12 month study.	Previous dietary surveys in the area estimate 700 cal (64 cal/kg) and 18g of protein per day (1.6g/kg). Calorie deficient	Experimental group drawn from two villages, controls from nearby ones. Cal. Prot. 1. (159) 300 10g (wheat flour, green grain, groundnut, sugar). 2. (200) --- Experimental group were those willing to participate.	- Distribution in charge of villagers. - Central, daily - Intake not reported - Dietary surveys in 40 test and 40 control children show no evidence of replacement.	Attained height and weights of experimental subjects consistently better than those of control subjects. Baseline data are however, not reported. Results suggest a protein-calorie effect.

two facts should be kept in mind. First, growth in weight, which includes growth in fat, may be responsive to caloric supplementation even when calories are not limiting; growth in height, however, which is more closely related to growth in muscle mass, will not. Secondly, growth in height may be responsive to caloric supplementation when energy is limited; this stems from the fact that under conditions of caloric limitations, some of the protein may be diverted to satisfy energy needs ²².

Therefore, the expected effect on growth in height and weight, given the nature of the supplements and the characteristics of the home diet, will be as follows:

Main limiting nutrient(s)	Characteristics of the home diet		Characteristics of the nutritional intervention		Both protein and calories
	Nearly or totally satisfactory	Calories	Protein	Calories	
Protein	Calories	*	Yes		Yes
Calories	Protein	Yes	Yes		Yes
Both	—	Yes	Yes		Yes

* Effect on growth in height, but not in weight.
 Yes Effect on growth in height and weight expected.
 No No effect expected.

This scheme is seemingly hard to test given the following. In most populations, deficiencies generally involve both proteins and calories; diets being exclusively deficient in calories but not proteins or inversely in proteins and not calories are hard to find. Secondly, only one of the situations, deficiency in protein and supplementation with calories, would predict no effect, and this only in height. However, till recently, most nutritionists would have predicted that calories alone would not have an effect on height growth given that protein was thought to be the main limiting factor in most malnourished populations.

With the exception of the two studies which gave negative results under conditions where an effect would have been expected ^{5, 6}, all other studies, as mentioned previously, suggest an association between protein-calorie supplementation and physical growth ⁷⁻¹⁸.

Of the studies reporting associations, all but two ^{16, 17} are in agreement with the proposed hypothesis. Thus, regardless of the limiting nutrient, giving proteins and calories is associated with better growth ^{7, 10, 11, 18}.

The best designs to test the hypothesis are those of Gopalan *et al* ⁸ and Malcolm ¹². In the former, calories were given to

calorie-deficient children while in the latter, protein and calories were given to protein-deficient children and compared to similar children receiving a supplement containing the same amount of calories but no protein (Table 1).

Gopalan's *et al* study⁸ found that under caloric limitations, calories will improve not only growth in weight but in height as well. In contrast, Malcolm's study¹² suggests that when not calories but proteins are limiting, protein supplementation will affect growth in height and weight while calories alone will affect growth in weight but not height.

The experiments of Subrahmanyam *et al*^{16, 17} and that of Bailey⁷ raise an important consideration. Given a situation of protein-calorie limitations, would additional protein holding the caloric intake constant produce an effect of proteins? The first studies seem to indicate that they do while the second does not. However, the degree of caloric limitation in Bailey's study⁷ is more acute than in Subrahmanyam *et al*'s studies^{16, 17} suggesting that as calories become more limiting, additional protein has no effect unless given in very high quantities^{23, 24}. King's *et al* study¹¹ also suggests that improving the protein quality in children with some degree of caloric limitation will also improve growth.

CONCLUSIONS

The experiments reviewed were shown to have a whole series of limitations which left many alternative hypotheses open. In spite of this, the evidence reviewed suggests that variation in protein and calorie intake are related to physical growth in mild-to-moderately malnourished children and that the true nature of this relationship is causal.

Moreover, the data reviewed suggest that the relative contribution of calories and protein to the association is dependent upon which nutrient is limiting in the home diet.

The problem of growth retardation is a pervasive one in poor societies of developing nations³. The corrective measures usually undertaken in the past have taken the form of expensive high-protein supplementation. In this regard we would like to reinforce the need to investigate which nutrients are most limiting in the home diet before such programs are instituted. We believe that in many areas of Latin America, increased consumption of the home diet, which would mean increases in both proteins and calories, would produce important improvements in growth.

RESUMEN

SUPLEMENTACION PROTEINICO-CALORICA Y CRECIMIENTO FISICO POSTNATAL: REVISION DE HALLAZGOS EN LOS PAISES EN DESARROLLO

Este trabajo constituye una revisión de la literatura referente a los efectos de la suplementación con proteínas y calorías sobre la velocidad de crecimiento en peso y en talla. Sólo se incluyen estudios de campo de países en vías de desarrollo, en niños con desnutrición moderada. Se plantean dos preguntas:

1. ¿Ha sido posible probar que existe una relación causal entre cambios en la ingesta de proteínas y calorías y cambios en la velocidad de crecimiento, y
2. ¿Varía el impacto de la suplementación alimenticia dependiendo de la cantidad de proteínas y calorías suministradas por el suplemento y por la dieta hogareña?

Se encontró que aun cuando los experimentos revisados tienen una serie de limitaciones, sí se puede inferir de estos estudios que la suplementación con proteínas y calorías está relacionada causalmente con el crecimiento físico. Además, se concluye que la contribución relativa de proteínas y calorías a esa relación depende de cuál de los dos nutrientes es más limitante en la dieta hogareña. En otras palabras, si las proteínas son las limitantes, éstas y no las calorías son las que producen un mejoramiento en la velocidad de crecimiento. Por el contrario, si las calorías son las limitantes, éstas por sí solas inducen una mayor velocidad de crecimiento. Estos hechos sugieren que antes de implementar programas costosos de suplementación, primero se debe investigar cuáles son los nutrientes más limitantes en la dieta.

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NUTRITION IN PREGNANCY

Studies in Central America and Panama ^{1, 2}

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SUMMARY

Nutrition during pregnancy is recognized as of great importance in public health, not only for the woman herself, but also for the impact that it may have on the present and future of the born child.

The pregnant state represents additional nutritional needs which have been estimated by expert groups, in a nutrient-independent manner. The percent increase in nutrient specific recommendations due to pregnancy varies with each nutrient. This would mean that the recommended dietary "pattern" for the pregnant woman differs markedly from that of the non-pregnant woman, but this matter needs further study and careful consideration.

In areas like Central America and Panama, where malnutrition is prevalent, pregnant women suffer from the same nutritional deficits as the general population. The main nutritional deficits are calories, protein, vitamin A, ribo-

1. This paper was presented at the Workshop on "Latent Effects of Malnutrition and Infection During Pregnancy as Determinants of Growth and Development of the Child", held in Guatemala, January 12-14, 1974. A condensed version appeared in: *Am. J. Dis. Child.*, 129: 427-430, 1975.
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INCAP Publication I-829.

Recibido: 10-11-1975.

flavin, iron and folates. In some instances like in the case of iron and calories, the deficit seems greater in the pregnant women than in the population at large. The studies give evidence that the new born children of malnourished mothers reflect in some aspects the biochemical changes found in the pregnant women.

INTRODUCTION

Public Health Significance of Nutrition in Pregnancy

Shortly after beginning my efforts to write an appropriate introduction for this presentation I gave up my hope to be original. The reason was the realization that the importance of maternal nutrition has previously been treated so much and so well. Through my reading, I came across the thoughts of the Technical Group of PAHO on "Maternal Nutrition and Family Planning in the Americas"¹ and could not resist quoting from one of its statements:

"Nutritional needs increase during pregnancy and lactation, and pregnant and lactating women form an important vulnerable group, exposed to special risks if their dietary needs are not met. In nearly all communities, the mother is chiefly responsible for care within the family of infants and dependent children, and poor maternal nutritional status may have serious consequences for such children. Since the mother is the necessary link between any health service and the fetus and young child, maternity and child health services should be combined.

From the immediate nutritional point of view, the maternal diet should provide sufficient of the nutrients required to maintain the mother and the fetus in good health during pregnancy, to support an adequate flow of breast milk without detriment to maternal nutritional reserves, and finally, to maintain maternal health between pregnancies. Yet it should not be forgotten that the children of today are the parents of tomorrow. The maintenance of a good nutritional state among growing children and adolescents is therefore a most important, possibly *the* most important, aspect of long-term nutritional policies".

Nutritional Needs Due to Pregnancy

No one would question the fact that the nutritional needs of women of reproductive age are substantially increased during pregnancy. Expert groups responsible for drawing recommended

dietary intakes have recognized this, and derived "allowances for pregnancy". In general the basis for these extra allowances are the physiological needs of the pregnant organism plus the necessary materials that ought to be accumulated for a normal product, plus, mainly in the case of calories, a reserve recognized to be necessary for lactation.

Data derived in such ways by different expert groups and committees of WHO and FAO were adapted to the Central American population in its environment², to produce the daily dietary recommendations presented in Table 1.

TABLE 1
DAILY DIETARY RECOMENDATIONS
INCAP, 1973

Nutrient	Pregnant ¹ (2nd & 3rd trimester)	Non- pregnant	Allowance for pregnancy	% Increase
Energy (kcal)	2400	2050	350	17
Protein (g)	60	45	15	33
Calcium (mg)	1100	450	650	144
Iron (mg)	28	28	—	—
Vitamin A (μg)	900	750	150	20
Thiamine (mg)	1.0	0.8	0.2	25
Riboflavin (mg)	1.3	1.1	0.2	18
Niacin equiv. (mg)	15.8	13.5	2.3	17
Ascorbic acid (mg)	50	30	20	67
Folate (free) (μg)	400	200	200	100
Vitamin B ₁₂ (μg)	3.0	2.0	1.0	50

¹ > 18 yrs old.

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Tables like this should not be presented without a statement about their meaning and interpretation: with the exception of calories, the recommended figures represent intakes considered necessary to satisfy the metabolic needs and maintain health in practically all persons in a specified group. This means that they should not be used as the only and absolute criterion to judge nutritional status of individuals. Deviations of individual intakes from the recommended figures are only suggestive, and are meaningful only as guidance to determine the types of further

information needed regarding past nutrient intake, clinical evidence, nutritional biochemical characteristics and growth and development. Since recommendations are set up at the upper level of the distribution curve of requirements most individuals consuming them would be amply covered in theory.

For calories the situation differs fundamentally. Because it is fully recognized that the consumption of more energy than actually spent is underisable, the estimated average *requirement* of the population is the recommended figure for the non-pregnant woman. For the pregnant woman, however, the Committee³ took a more liberal approach, recognizing that "a safe level of energy intake is a basic requirement to ensure satisfactory nutrition for the fetus and breast-fed infant". The recommended intake therefore is set to provide for a storage through pregnancy of about 36,000 kcal as adipose fat reserves.

The last column of this Table is puzzling. It indicates that if the diet of the woman before pregnancy is adequately supplying all the nutrients in amounts and proportions according to the recommended intakes, then a simple increase in pregnancy of 17% in consumption of that diet to satisfy the increase in caloric need, would leave in deficit several nutrients, particularly calcium, ascorbic acid, proteins, folate and vitamin B₁₂. It implies the need for a drastic change in the dietary *pattern* during pregnancy. It makes one wonder if this peculiar pregnancy pattern is real or the outcome of the relative enthusiasm and success of specialists in some nutrients over others.

Table 2 presents the results of an exercise carried out to estimate in practical terms how a pregnant woman in a typical rural village in Guatemala could fill her dietary gap due to pregnancy. It can be seen that four spoonfuls of black beans, two tortillas, half an ounce of cheese, half of a tomato and one leaf of cabbage would accomplish the job leaving an unimportant deficit in calcium and niacin and a notorious deficit in vitamin A. The foods were selected among those available to the community which form part of their regular diet. Under these ecological conditions, the gap in vitamin A cannot be filled but by supplementation. The last horizontal line of the Table gives an "upper limit" estimate of cost. Between 6 and 7 Quetzales (1 Quetzal = 1 U.S. Dollar) would be spent in the last 6 months of pregnancy for these extra foods.

TABLE 2
 "COST" OF PREGNANCY
 (Rural Indian Community, Altiplano of Guatemala, 1972)

Nutrient	Beans 4 spoons (cooked)	Tortilla 2 U. (yellow)	Cheese 15 g	Tomato ½ U.	Cabbage 1 leaf	Total	Allowance for preg- nancy (1)
Energy (kcal)	108	186	65	5	6	368	350
Protein (g)	7	5	4	0.2	0.4	16.6	15.0
Calcium (mg)	28	142	341	1	10	522	650
Iron (mg)	2.4	2.2	0.2	0.1	0.2	5.1	0
Thiamine (mg)	0.2	0.1	0.05	0.01	0.01	0.37	0.20
Riboflavin (mg)	0.06	0.04	0.01	0.01	0.01	0.2	0.2
Niacin (mg)	0.6	1.0	0	0.1	0.1	1.9	2.3
Retinol (µg)	0	14	29	13	2	58	150
Cost (cents)	1.3	1.0	1.0	0.5	0	3.8	—

1 INCAP, 1973.

NUTRITION OF PREGNANT WOMEN IN CENTRAL AMERICA

Dietary Intake Patterns and Nutrient Intake

Following is an account of some studies which have been done at INCAP about dietary patterns and nutrient intake of women, as these may be affected by pregnancy and lactation.

Beteta and Flores⁴ carried out in 1963 a dietary survey to assess directly the nutrient intake of pregnant and lactating mothers in a Guatemalan village. At the same time they collected data on the general population. A lower adequacy was noticed for the lactating women. Observation of the actual intakes revealed that in general this was caused by their higher recommended allowances rather than by a lower consumption. An exception is vitamin A, in which case, both a decreased consumption and an increased recommended allowance resulted in a very low adequacy. In the case of this nutrient, pregnant women are in the same situation. In general, therefore, the pregnant women increased their nutrient intake in this village, to compensate for the increased demand, with the exception of vitamin A; but the lactating women did not.

A similar conclusion with regard to pregnancy is derived from the study conducted later (1967-68) by Flores *et al.*⁵ in two "ladino" villages in the rural area of Guatemala. Table 3 summarizes these findings. In this study the data were collected by monthly 24-hour recalls in a longitudinal way and the results are pooled from the two villages for the first, second and third trimesters. The general trend in both villages is an increase in food consumption during the last two trimesters. This comprises mostly corn and vegetable foods representing an increment in caloric intake of around 400 cal/day over the 1500 cal being consumed during the first trimester. This was accompanied by a variable increase in the intake of other nutrients. Animal protein was stationary at a low level of intake or even tended to decrease in one of the villages. Please notice that, calories, iron, riboflavin and vitamin A are, of the nutrients estimated, those in most marked deficit. Calories are definitely more deficient than proteins; the intakes would be insufficient even for a non-pregnant non-lactating woman. An interesting piece of information is the consistent decrease in food intake in the lactating woman in relation to the third trimester of pregnancy which translates into about 200 calories but proportionally affects more drastically riboflavin, vitamin A and vitamin C. The reasons for this are unknown but the fact

suggests a change in dietary pattern which may have cultural roots. The three last vertical columns correspond to 43 rural low socioeconomic children of Guatemala also, and they are included for the sole purpose of illustrating the fact that the relative adequacy figures are surprisingly similar to those for the pregnant mother: the same nutrients occupy the positions of larger deficits principally calories, vitamin A and riboflavin. This emphasizes the position of the Technical Group of PAHO on Maternal Nutrition and Family Planning in the Americas¹ who stated: "It is unrealistic to consider the nutrition of pregnant and nursing mothers in isolation. They are members of their family groups and of their social environment. Public health measures should therefore be directed toward the improvement of nutritional conditions in societies as a whole, as well as in family groups".

The question of whether the dietary pattern is changed by women during pregnancy was also investigated in a qualitative study by Arroyave *et al.*⁶ in Guatemala. They surveyed 14 pregnant women of each, the high socioeconomic and the low socioeconomic groups. The women in the high socioeconomic group changed their pattern more, introducing more milk, eggs, fruits and vegetables and reducing cereals and fats. This change suggests the influence of nutrition education. In the low income group few women changed their pattern and more their total food consumption. The only frequent change was an increase in fruits.

With the extensive data collected during the Central American Nutrition Survey⁷ we have made a comparison of the adequacy of caloric intake of families who had pregnant and/or lactating women among them, with those families without. To express the results in some standardized manner we have calculated the percent of families in each category who had an adequacy of 75% or less compared with the weighted recommended allowances. The effect is shown in Table 4. The presence of pregnant women resulted in a lower adequacy in 4 countries. It is obvious that the effect observed may be caused by (a) the increased recommended allowances of pregnancy and lactation combined with a decrease in absolute nutrient intake; and (b) by the increased recommended allowances with no increase in nutrient intake to compensate for the higher demand. In the case of lactation at least the data previously discussed (Table 3) indicate that the explanation is that given under (a). Whatever the case, the results emphasize the need to give attention to this problem through nutrition education and supplementation programs.

TABLE 3
ADEQUACY OF DIETARY INTAKE
 (Low Socioeconomic Rural, Guatemala)

Nutrient		Pregnant (Trimester)			Lactating	Child (2 yrs.) Adequacy % 5		
		1rst (n=20)	2nd (n=57)	3rd (n=57)	(n=36)	(n=43)		
						Q1	M	Q3 6
Energy ⁽³⁾ (kcal)	Intake	1418	1723	1819	1599			
	Adeq. % ⁽¹⁾	64	72	76	62	50	66	80
	Adeq. % ⁽²⁾	69	84	89	78			
Protein ⁽³⁾ (g)	Intake	39	50	54	58			
	Adeq. % ⁽¹⁾	87	83	90	85	57	74	97
	Adeq. % ⁽²⁾	87	111	120	129			
Animal protein	Intake	8	7	9	10	—	—	—
Calcium ⁽³⁾ (mg)	Intake	768	967	1012	887			
	Adeq. %	171	88	92	81	47	69	100
Iron ⁽³⁾ (mg)	Intake	17	17	20	21			
	Adeq. %	61	61	71	75	43	71	107
Riboflavin ⁽³⁾ (mg)	Intake	0.68	0.71	0.79	0.58			
	Adeq. %	57	55	61	41	26	46	66
Thiamine ⁽³⁾ (mg)	Intake	0.81	0.99	1.07	1.03			
	Adeq. %	90	99	107	103	68	92	122
Vitamin A ⁽⁴⁾ (mg)	Intake	0.47	0.53	0.75	0.34			
	Adeq. %	36	33	47	16	10	30	69
Vitamin C ⁽³⁾ (mg)	Intake	36	29	39	13			
	Adeq. %	120	58	78	26	16	60	108

- (1) Adequacy relative to recommendations for pregnant women.
 (2) Adequacy relative to recommendations for non-pregnant women.
 (3) INCAP, 1973.
 (4) INCAP, 1965.
 (5) INCAP, 1968.

Q1 = First quartile; M = Median; Q3 = Third quartile

TABLE 4

ADEQUACY OF CALORIE INTAKE OF FAMILIES WITH PREGNANT OR LACTATING WOMEN COMPARED TO THOSE WITHOUT

(Rural Area, 1965-67)

(Percent of families with an adequacy of 75% or less)

	Families with pregnant	Families with lactating	All families without
Guatemala	14	18	12.0
El Salvador	33	26	16.0
Honduras	24	43	31.0
Nicaragua	25	49	24.0
Costa Rica	50	37	28.0
Panama	28	36	15.0

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Biochemical-Nutritional Characteristics

The following is a review of the studies which have been carried out by INCAP on the nutrition of pregnant and lactating women. In 1958 Arroyave *et al.*⁸ reported an investigation of the riboflavin nutritional status of pregnant women from a low-medium socioeconomic group in Guatemala City. The samples were 33 mothers attending the prenatal care clinic of the Social Security Institute. At the time of the study all were between the 27th and the 32nd weeks of pregnancy.

To judge the state of riboflavin nutrition the subjects were submitted to a "load-retention test", which consisted in the parenteral administration of 1 mg of pure riboflavin and the measurement of the absolute quantity of the vitamin excreted in the urine during the following 4 hours. The results are shown in Figure 1. It was concluded that only 13 of the 33 women had excretions compatible with adequate intakes of riboflavin, that is, 4-hour excretions of 200 μ g or higher. Six of them retained over 90% of the injected dose, indicating high "insaturation" of the tissues. The Figure also illustrates, as point of practical importance, the close relationship between the intake of animal food sources of riboflavin, principally milk, with "tissues saturation", indicating the minor role which the vegetable foods of the diet play as sources of this important vitamin.

In another investigation reported in 1960, Arroyave *et al.*⁶ compared some biochemical-nutritional indices between two groups of pregnant women: forty-seven women from the low socioeconomic level (Amatitlán, Guatemala) and 26 of high socioeconomic level (Guatemala City). This study, which included the three trimesters of pregnancy showed significantly lower levels of red blood cell riboflavin, serum vitamin A and carotene, hemoglobin and hematocrit, for the low socioeconomic group. The total serum proteins did not differ. Albumin was not determined.

Beaton, Arroyave and Flores⁹ made an attempt to find changes in plasma proteins and their paper and starch-gel electrophoresis fractions which would indicate inadequate protein nutrition in pregnant women of low socioeconomic level. The findings were compared with those in pregnant women of the high socioeconomic group. The values were found essentially the same in both groups. The authors suggest several possible explanations: "1) due to nutritional and physiologic adaptations, dietary protein requirements do not increase appreciably during pregnancy and lactation; 2) protein intake, although frequently below the recommended levels, was sufficient, even in the low socioeconomic groups, to meet the added requirements of pregnancy and prolonged lactation; 3) the methods employed were not sufficiently sensitive to detect the effects of a dietary inadequacy".

Beteta⁴ in his study of a group of pregnant women of a low socioeconomic ladino rural village in Guatemala, found biochemical evidence of inadequate riboflavin intake, that is, low urinary riboflavin excretion and reduced levels of red blood cell riboflavin. Furthermore, he found a pattern of plasma free-amino acids suggestive of an inadequate protein intake, as shown by a low ratio of valine/glycine (Table 5). It is interesting that the new born children from these mothers (cord blood) also showed this alteration indicating an effect of the nutrition of the mother. The significance of this finding in terms of the nutrition and development of the fetus may be of importance.

In a recent study being conducted at INCAP with the objective of determining differences in placental composition in two groups of urban mothers of low and high socioeconomic level in Guatemala¹⁰, a number of biochemical and physical measurements were taken in order to characterize the subjects' nutritional status. The socioeconomic level was defined by the monthly family income, environmental sanitation of the house and educational level of the mother. Both groups were matched for age, parity, interval with the previous delivery and absence of severe disease during pregnancy. Only the uncomplicated full-term pregnancies

TABLE 5
PLASMA VALINE AND GLYCINE IN POPULATION GROUPS
HAVING DIFFERENT NUTRITIONAL CHARACTERISTICS

Group	Nº	Valine (mg/100 ml)	Glycine (mg/100 ml)	Ratio
1 Pregnant women Guatemala City (UIU) ⁽¹⁾	5	1.491	1.210	1.298
2 Pregnant women S. Ant. P. (LIR) ⁽¹⁾	6	0.998	1.599	0.636
3 Non-pregnant women S. Ant. P. (LIR)	7	1.447	2.643	0.587
4 Newborn children Guatemala City (UIU) ⁽²⁾	5	2.392	2.531	0.947
5 Newborn children S. Antonio La Paz (LIR) ⁽³⁾	6	2.002	2.970	0.710
6 Well-nourished children 3-6 years of age	5	1.679	1.606	1.093
7 Children with kwashiorkor 2-6 years of age	6	0.275	1.577	0.184
8 Children with marasmus 1 year of age	1	0.456	1.266	0.360
	1	0.584	1.596	0.366

(1) UIU Upper income urban; LIR Low income rural. Ninth month of pregnancy.

(2) Cord blood from group 1.

(3) Cord blood from group 2.

resulting in male newborns were included. Special attention was given to five nutrients which were expected to be discriminatory variables in the diets of the two groups: proteins, calories, vitamin A, riboflavin, iron and folic acid. The selection was made on the basis of the dietary and nutritional findings of the population at large to which the pregnant belonged. Some pertinent results of this study will be discussed here in some detail.

Protein, calories. The distribution of urinary excretion of urea per gram of creatinine shown in Figure 2, was significantly different between the two groups when a value of 4 g urea N/g creatinine was taken as the discriminatory level. A rationale, derived *a posteriori* from basic nutrition concepts, gives biological meaning to the ratio of 4 g urea N/g creatinine: the urinary urea N/creatinine ratio determined in "fasting" urine from pregnant women ingesting their recommended allowance of ideal protein could be predicted like this: the safe level of ideal protein intake for a 55 kg woman is 29 g/day³. For the Central American woman weighing 51.1 kg the need is 27 g/day². To this, 9 g/day are added for pregnancy during the second and third trimesters.

$$27 + 9 = 36 \text{ g/day}$$

With this low intake about 70% of the urinary nitrogen is expected to be urea N¹¹⁻¹⁴. Therefore, $36 \times 0.7 = 25.2$ g protein equivalent. Then, $25.2/6.25 = 4$ g urea nitrogen. One can estimate that the desirable creatinine excretion per 24 hours of the women would be about 1.0 g. The average plus 1 S.D. for the high socioeconomic women is 1.0 g of creatinine per 24 hours. Therefore, an excretion of urea N of less than 4 g/g creatinine (or 24 hr) is undesirably low.

An immediate biochemical consequence of the above is a marked highly significant difference in the Whitehead's plasma non-essential/essential amino acid ratio which is obviously abnormally elevated in the women of the low socioeconomic group as shown in Figure 3. The results of the previous study already mentioned are further documented and confirmed, demonstrating unequivocally that the amino acid ratio of the newborn is also markedly affected by the nutrition of the pregnant woman. The difference is also highly significant ($P < 0.01$) and is also shown in Figure 3.

A gross manifestation of this nutritional limitation in proteins should be revealed by physical measurements, but of course, other deficiencies, particularly caloric, confound the interpretation. The

TABLE 6
SERUM PROTEIN FRACTIONS IN PREGNANT WOMEN AT
DELIVERY IN TWO SOCIOECONOMIC GROUPS

Socioeconomic level		Albumins	Globulins (mg/100 ml)			
		(mg/100 ml)	α_1	α_2	β	γ
High	N	18	18	18	18	18
	\bar{x}	3.28	0.43	0.92	1.14	1.25
	SD	0.294	0.100	0.245	0.190	0.243
Low	N	30	30	30	30	30
	\bar{x}	3.49	0.44	0.91	1.31	1.15
	SD	0.222	0.055	0.127	0.193	0.253
t		2.50*	0.37	0.017	3.09**	1.41

* $P < 0.05$.** $P < 0.01$.

Incap 75-1155

TABLE 7
SERUM PROTEIN FRACTIONS IN CORD BLOOD IN TWO
SOCIOECONOMIS GROUPS

Socioeconomic level		Albumins	Globulins (mg/100 ml)			
		(mg/100 ml)	α_1	α_2	β	γ
High	N	20	20	20	20	20
	\bar{x}	3.23	0.18	0.38	0.46	0.98
	SD	0.336	0.170	0.071	0.090	0.208
Low	N	30	30	30	30	30
	\bar{x}	3.38	0.20	0.41	0.50	1.10
	SD	0.400	0.055	0.120	0.185	0.182
t		1.43	0.52	1.11	1.05	2.18*

* $P < 0.01$.

Incap 75-1154

TABLE 8
PERCENT OF WOMEN WITH DEFICIENT AND LOW SERUM
FOLATE LEVELS

Group	"Deficient" (<3.0 ng/100 ml)	"Low" ($3.0-4.9$ ng/100 ml)	Origin
<i>High Socioeconomic:</i>			
Pregnant (9)	0%	11%	Guatemala City
<i>Low Socioeconomic:</i>			
Pregnant (121)	17%	41%	Guatemala City
Non-pregnant (535)	33%	34%	Rural Central America

Figures in parenthesis are number of cases.

Incap 74-6

weight for height of the women of the low socioeconomic group is significantly lower¹⁰, and the tricipital skinfold thickness is also lower¹⁰, which indicates a deficit in caloric adequacy. The creatinine excretion per 24 hours is a reflection of total muscle mass. In Figure 4 the values are shown. The distribution of the values is not normal and, accordingly, instead of comparing the means, it appeared more appropriate to compare the distributions of the values. For the purpose, a set reference point was chosen, namely the median value for the high socioeconomic group. The proportion of values below this reference point in the low socioeconomic group was compared with the expected value of 50%. A difference was found, as 22 out of the total of 29 low socioeconomic women fell below the reference value. This, of course, could be normally due to the difference in height of the women, since the averages are 150 cm for the low and 162 cm for the high socioeconomic groups, respectively. This question may be resolved by expressing the creatinine excretion per centimeter of body height (Fig. 5). When this is done, a difference persists in favor of the high socioeconomic group, indicating a relative protein depletion in the low socioeconomic group.

If the caloric reserves (adipose tissue) were the same in both groups, one would expect the creatinine coefficient (mg creatini-

ne/kg) to be also lower in the low socioeconomic women. The results are shown in Figure 6. The difference in the distribution of values tested as described before, shows the opposite, that is, in the low socioeconomic group, the proportion of creatinine coefficients above the set reference point (74%), is significantly larger than 50%. These higher creatinine coefficients for the low socioeconomic group indicate that the lower weight for height of these women is due partly to a decreased protein mass, plus an even more drastic decrease in caloric reserve. All these data demonstrate the effects of a caloric limitation in the dietary intake of the women of low socioeconomic level.

The plasma protein fractions (Tables 6 and 7) indicate that the calorie-protein deficit noted has not resulted in an abnormal picture. In fact, practically all the fractions tend to be higher in the low socioeconomic women, but the difference is significant only for albumin and beta globulin. This normal or increased plasma protein in chronically undernourished pregnant women has been described before and is attributed to a reduction in the physiological increase in blood volume characteristic of the last stages of normal pregnancy⁶. It could be that a relative predominance of caloric over protein deficit is responsible for this "maintenance" of the plasma protein picture, in the same manner as in marasmic children¹⁴.

Vitamin A. Average serum retinol levels of the mothers during delivery and the corresponding cord blood are presented in Figure 7. The high socioeconomic group had higher values but while the difference in the pregnant women was highly significant, in the corresponding cord bloods it was not when assessed by "t" test. Nevertheless, the distribution of the cord blood values points to a marked difference. For general populations, values below 10 $\mu\text{g}/100\text{ ml}$ are considered "deficient"¹⁵. Although this criterion may not be directly applicable to cord blood, no better criterion is available. On this basis, 11 out of 30 cases (37%) in the low socioeconomic group, while only 3 out of 20 (15%) in the high socioeconomic group, are in the "deficient" category.

Figure 8 illustrates the relationship between the retinol levels in the mothers' serum and those in the cord blood serum. There is a tendency towards a correlation which did not reach significance. However, the analysis by arbitrary discriminatory intervals of the womens' values indicates that as these increase, the cord blood values increase also, but at a lower rate. This interesting relationship indicates a placental barrier to retinol,

perhaps as a protecting mechanism to the sensitive tissues of the fetus against unfavorably high concentrations of retinol.

Riboflavin. The data from previous studies discussed already had given evidence of inadequate riboflavin in the diet. Since the urinary excretion of this water-soluble vitamin is related to intake¹⁶, it was measured in the two groups of women and related to the excretion of creatinine. Figure 9 compares the distribution of the results showing that more than half of the values of the low socioeconomic group fall in the inadequate categories¹⁵ while 90% of the values in the high socioeconomic group are either "acceptable" or "high". The difference is highly significant. Although the functional and clinical consequences of this for the mother of the child were not measured, it is obvious that the dietary supply of riboflavin to the mothers of the low socioeconomic group is notoriously below desirable levels.

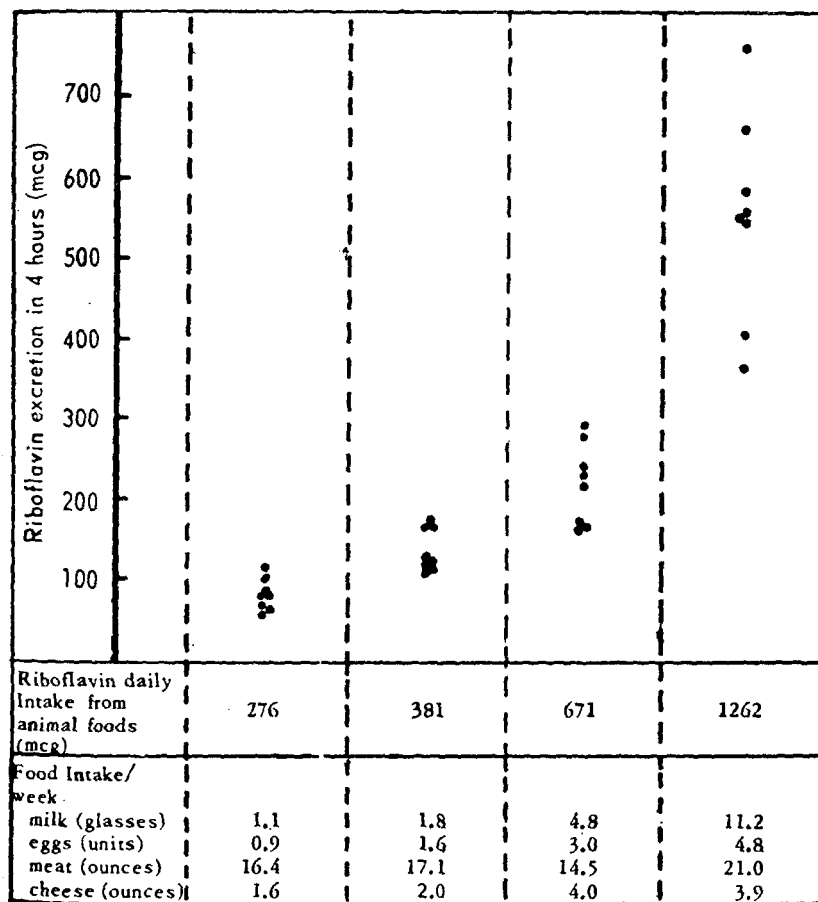
Anemia studies (iron and folates). The problem of anemia in the population of Central America was evaluated during the nutrition survey⁷, and the data obtained permit a comparison of pregnant women with their non-pregnant/non-lactating counterparts. The results show that pregnant women in all the six countries have a higher prevalence of iron deficiency indicated by the degree of transferring saturation. This is shown in Figure 10.

The role that folate nutrition may be playing as a limiting nutrient in the etiology of anemias in the populations of the area, and particularly in pregnant women, has been investigated at INCAP by Viteri¹⁷. For the general population, the evidence points to the fact that folates are limiting in the diets but that their deficiency does not manifest itself hematologically because iron is the first limiting factor for hematopoiesis giving a microcytic hypochromic picture. When iron is administered to these people the already low folate blood levels fall even further and folate becomes the limiting hematopoietic nutrient.

Pregnant women are not an exception to this. In the low socioeconomic group the percent of cases with a "deficient" (<3 ng/100 ml) and "low" (3-4.9 ng/100 ml) serum levels was very high in an urban group of pregnant women attending a public hospital in Guatemala^{10, 17} as shown in Table 8. The data in non-pregnant low socioeconomic women⁷ are included to show that the prevalence of "deficient" and "low" values is also very high, but the sample is not quite comparable since the latter comprises all the Central American rural area. Of nine pregnant women belonging to the high socioeconomic urban group in

Guatemala City¹⁰ none had "deficient" serum levels and only one was with a "low" value.

In conclusion, iron seems to be the first hematopoietic limiting factor, its deficiency obscuring the manifestations of folate deficit in the body. This is true for the general population of adults and it reflects in the pregnant women.

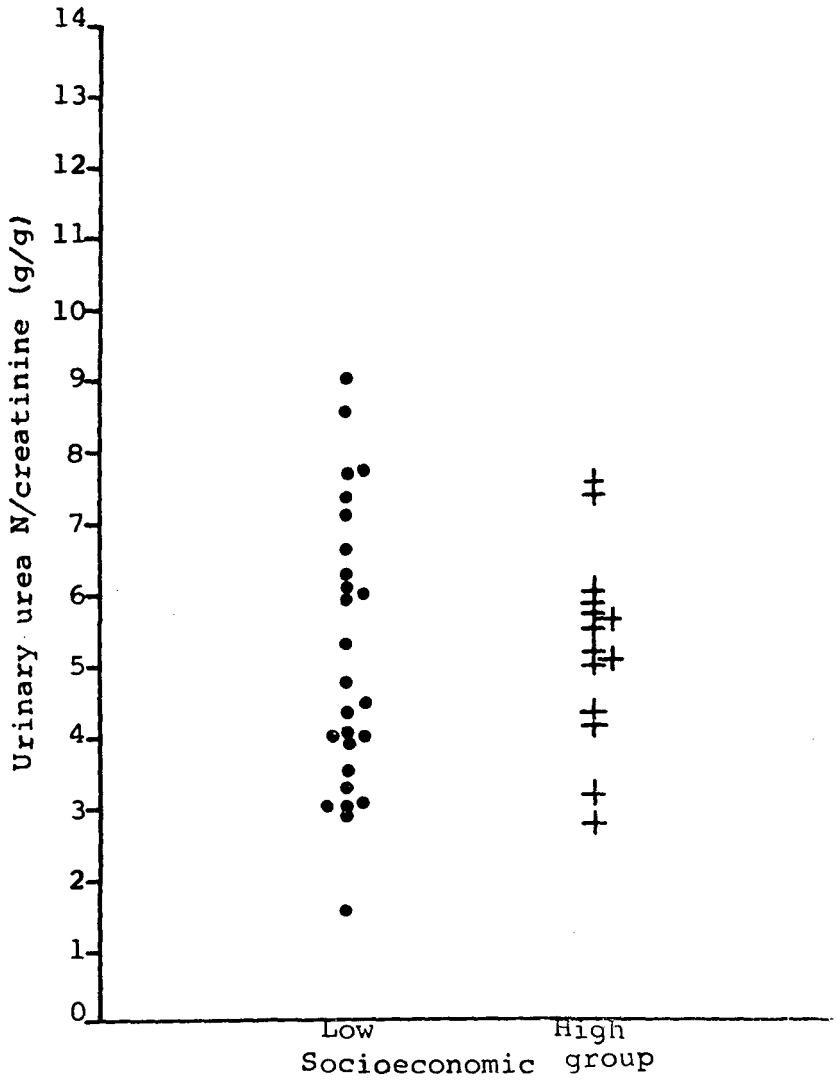


MEDIAN: (171 mcg urinary riboflavin in 4 hrs)

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Fig. 1

Excretion of urinary riboflavin in pregnant women (Amatitlán, Guatemala, 1958).

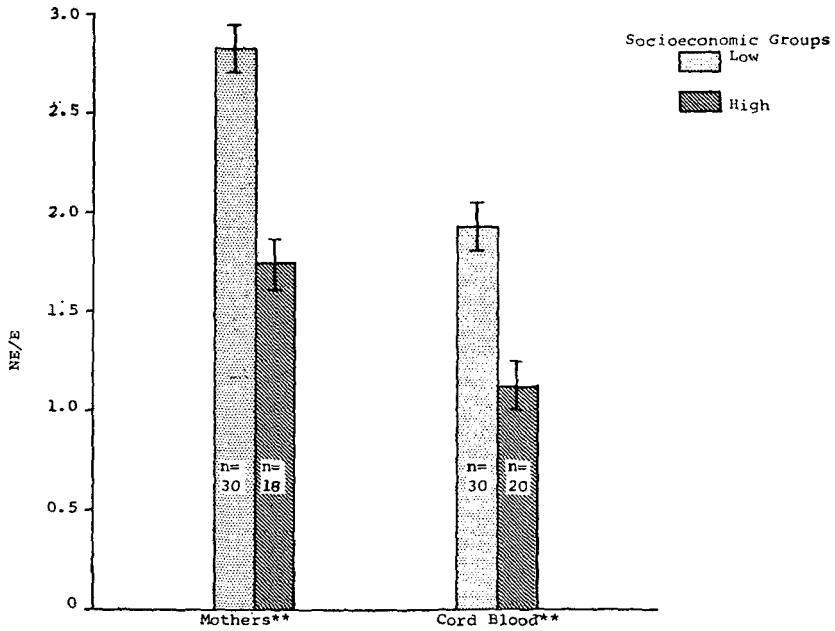


¹Shortly before delivery

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Fig. 2

Urea nitrogen/creatinine ratio in pregnant women of two socioeconomic groups in Guatemala.



(1) At delivery
 ** P < 0.01

Incap 73-1693

Fig. 3

Non-essential/essential serum amino acid ratio (NE/E) of pregnant women and cord blood in two socioeconomic groups.

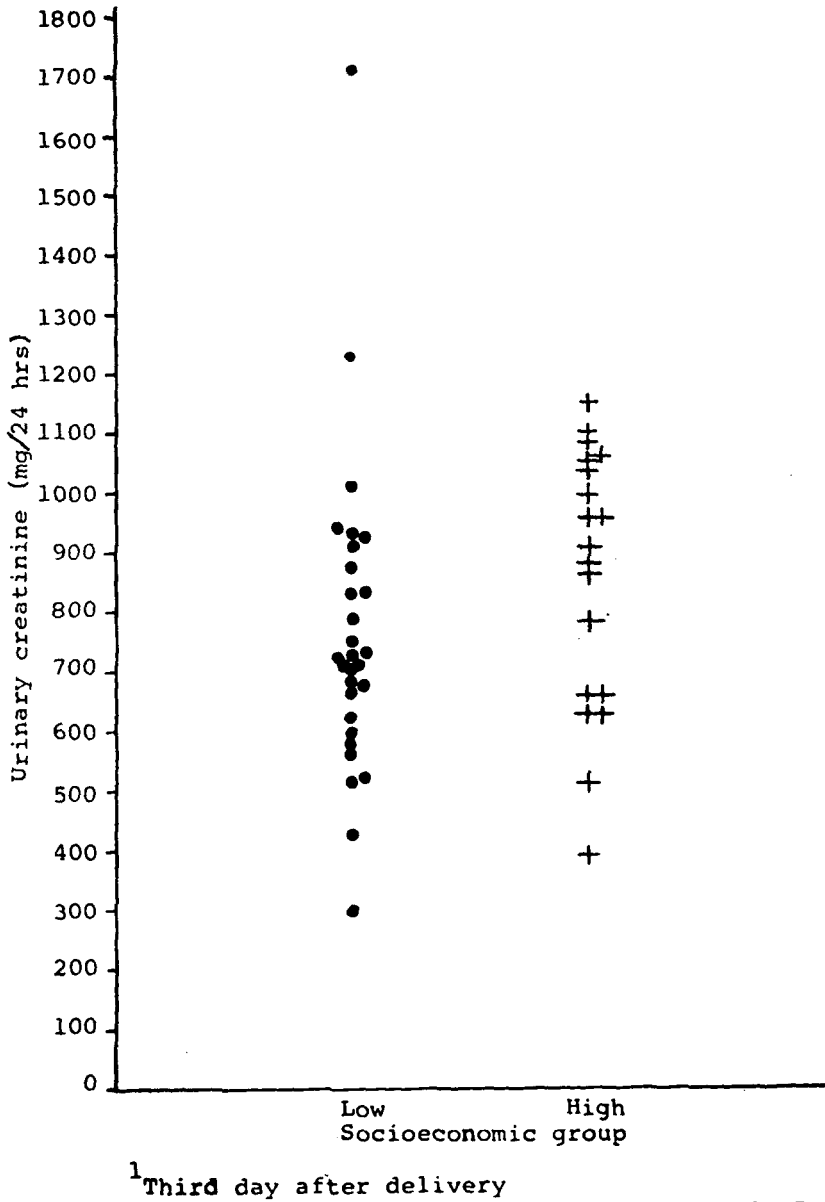
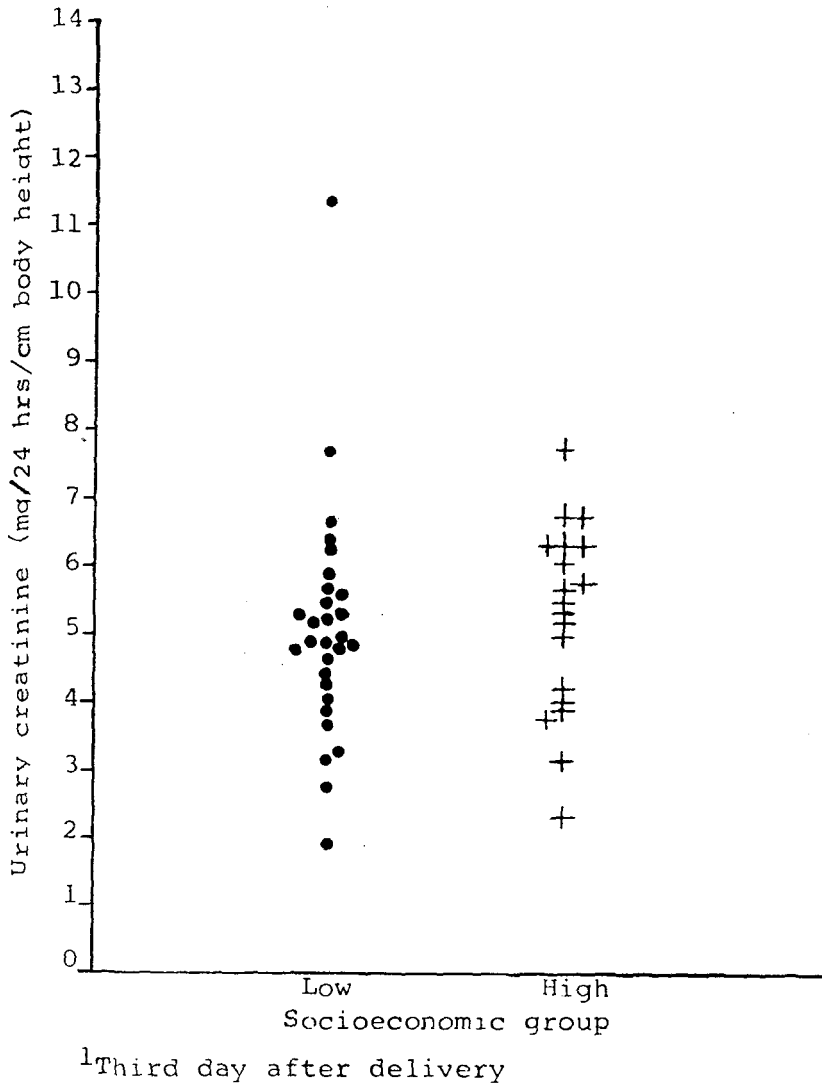


Fig. 4

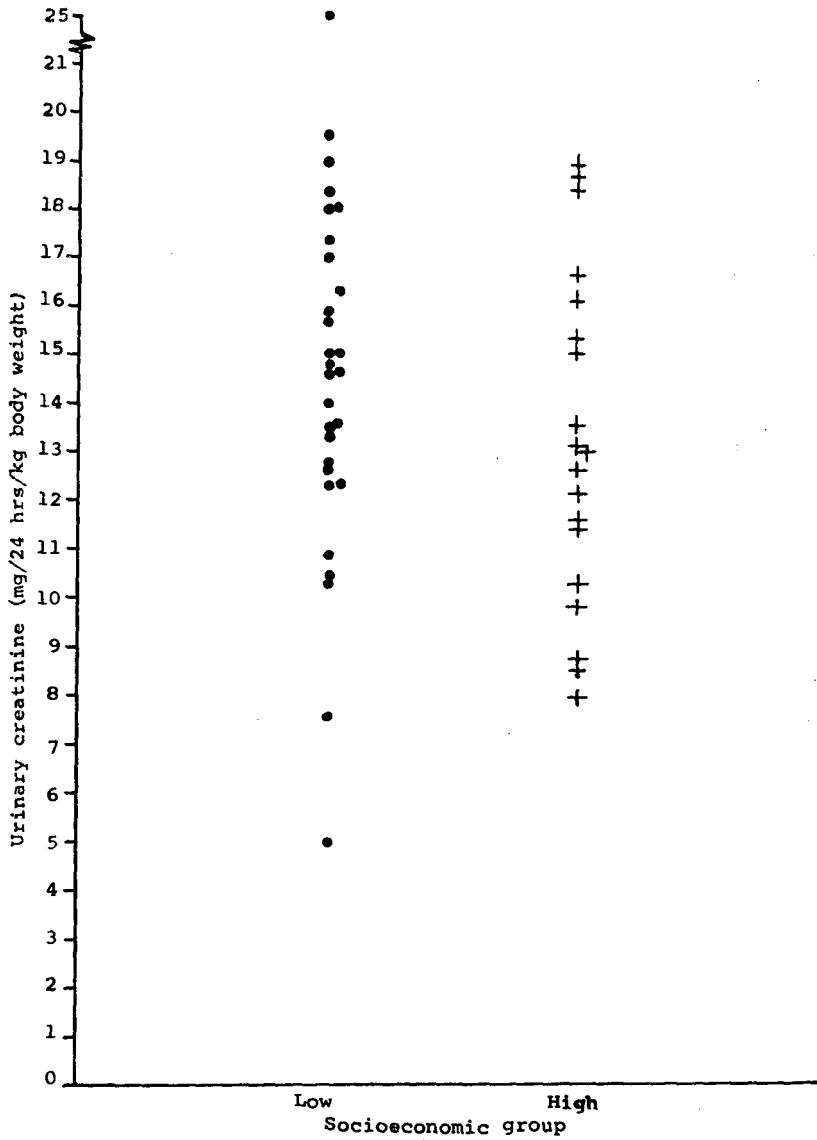
Creatinine excretion in women of two socioeconomic groups in Guatemala.



Incap 74-8

Fig. 5

Creatinine excretion per centimeter of body height in women of two socioeconomic groups in Guatemala.

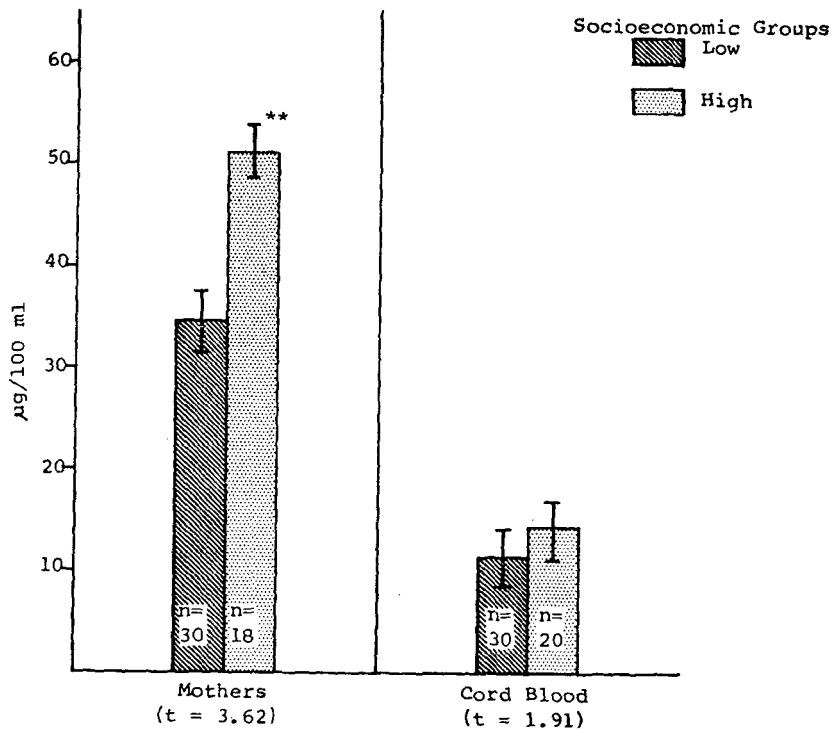


¹Third day after delivery

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Fig. 6

Creatinine coefficient in women of two socioeconomic groups in Guatemala.



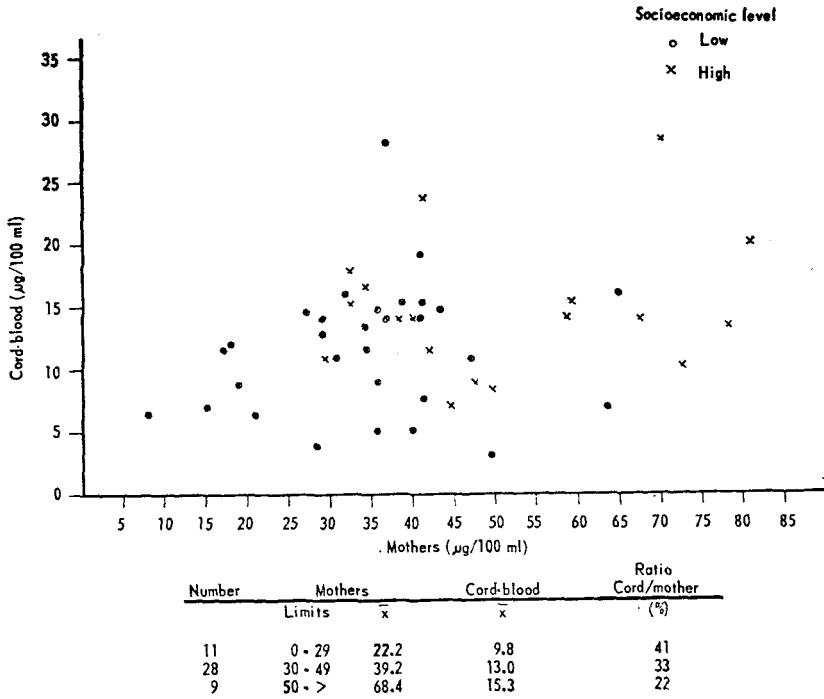
(1) At delivery

** P < 0.01

Incap 73-1689

Fig. 7

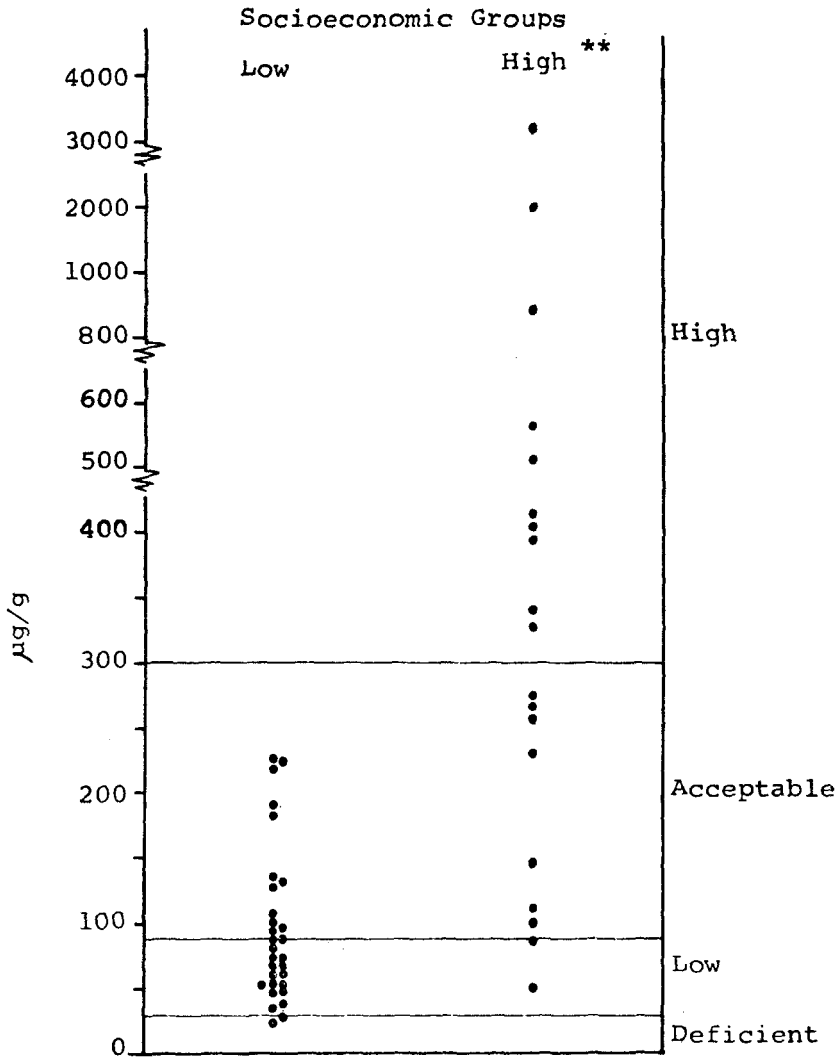
Serum vitamin A in pregnant women and cord blood in two socioeconomic groups.



Incap 75-699

Fig. 8

Serum vitamin A in pregnant women and cord blood of two socioeconomic groups.



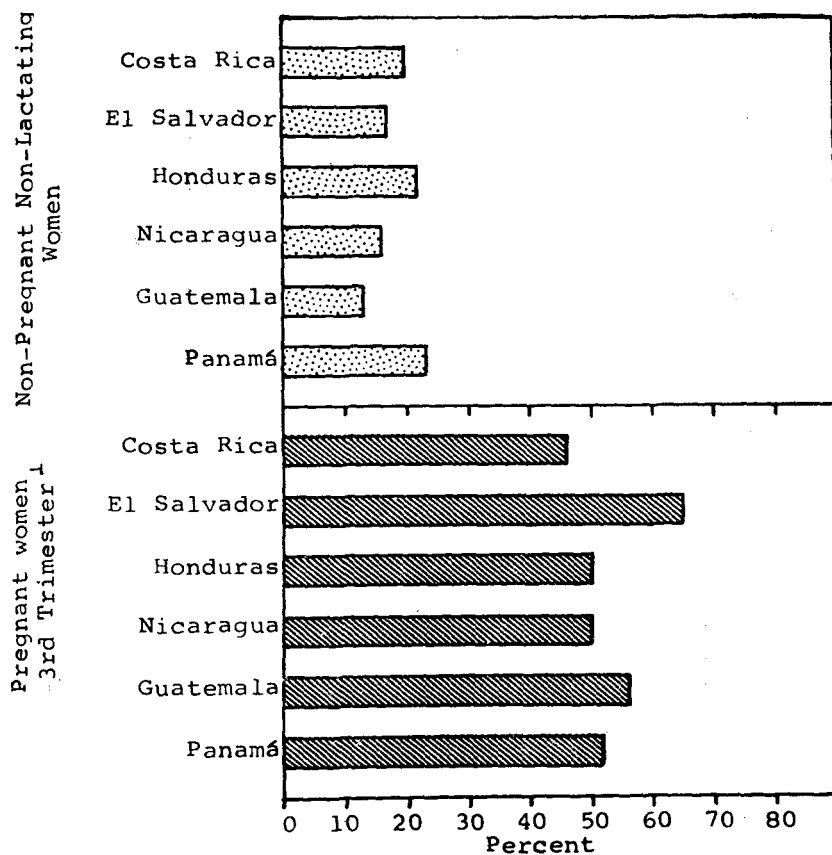
(1) Just before delivery

** $P < 0.01$

Incap 73-1687

Fig. 9

Urine riboflavin of pregnant women of two socioeconomic groups.



1 Panamá second trimester of pregnancy

Incap 74-57

Fig. 10

Percent of pregnant women with deficient transferrin saturation (<15%), in Central America and Panama (1965-1966).

RESUMEN

NUTRICION DURANTE EL EMBARAZO
Estudios en Centro América y Panamá

La nutrición adecuada durante el embarazo es de gran importancia en salud pública, no sólo en función de la mujer misma, sino también por el impacto que ello pueda tener sobre el presente y futuro de su hijo. El estado fisiológico del embarazo representa mayores necesidades nutricionales, las que han sido estimadas por grupos de expertos que han dictaminado sobre nutrientes específicos, considerados en general independientemente unos de otros. El aumento porcentual en las recomendaciones para cada nutriente debido al embarazo varía de uno a otro en magnitud. Esto significaría que el patrón dietético recomendado para la mujer embarazada difiere notablemente de aquél establecido para la mujer no embarazada; esta observación, sin embargo, amerita mayor estudio y cuidadosa consideración.

En áreas como la de Centro América y Panamá donde prevalece la desnutrición, las mujeres embarazadas sufren de los mismos déficits nutricionales que la población general. Los principales déficits nutricionales en esta zona son los de energía, proteínas, vitamina A, riboflavina, hierro y folatos. En algunos casos, como en el de hierro y energía, los déficits parecen ser mayores en la mujer embarazada que en la población general. Los estudios comentados en este artículo arrojan evidencia de que los niños recién nacidos de madres desnutridas reflejan en algunos aspectos las alteraciones bioquímicas que se encuentran en la mujer embarazada.

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TRABAJOS DE INVESTIGACION

ACTIVIDAD DE CREATIN-FOSFOQUINASA EN SUERO: ANALISIS DE LA INFORMACION SUMINISTRADA POR DIFERENTES FORMAS DE EXPRESION DE LOS RESULTADOS¹

Nelda E. Marcilla de Parada, María E. Río² y Juan C. Sanahuja

RESUMEN

La utilidad de la determinación de CPK en suero para el diagnóstico y evaluación de la malnutrición humana se estudió mediante un modelo experimental con ratas subnutridas alimentadas con dietas de bajo contenido proteico o desequilibradas en su composición de aminoácidos. El estudio sistemático de las variaciones de CPK en suero de rata en relación con la dieta, se llevó a cabo poniendo un énfasis especial en la calidad de la información suministrada por cuatro formas distintas de expresión de la actividad enzimática. Los resultados obtenidos se expresaron como: 1) Actividad específica, 2) Actividad por ml de suero, 3) Actividad total circulante y 4) Actividad total por 100 g de peso corporal. El análisis estadístico de los resultados demostró: a) La actividad expresada por mg de proteína o por ml de suero no guarda concordancia con los fenómenos fisiológicos que se sabe son inducidos por la ingestión de las dietas experimentales a nivel del músculo; por lo tanto, estas dos formas de expresión deben ser descartadas en estudios de malnutrición. b) Cuando se expresan los datos como actividad total en suero, la información aportada es similar a la que provee el Índice Creatinina/Talla de más fácil realización. c) La expresión a peso constante demostró ser la más adecuada para proporcionar información acerca de la masa muscular de animales bajo condiciones controladas de experimentación. La necesidad de conocer: volumen plasmático, edad, peso real e historia previa del paciente, la hacen inaplicable a estudios en humanos.

INTRODUCCION

El músculo es uno de los tejidos que se ve más afectado por la malnutrición proteica. Se han propuesto varios métodos para

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Recibido: 29-10-1975.

evaluar el estado nutricional de los individuos midiendo el desarrollo muscular, ya sea por métodos físicos^{1, 2} o bioquímicos; así, la excreción urinaria de creatinina, expresada como "índice creatinina/talla"³, ha demostrado guardar una buena correlación con el grado de depleción muscular.

La creatin-fosfoquinasa (CPK)-ATP: creatina fosfotransferasa (E.C. 2.7.3.2.), localizada en músculo es la enzima responsable de la captación y almacenamiento de la energía utilizable en la contracción muscular. Los niveles enzimáticos normales en suero son muy bajos y sólo aumentan notablemente cuando el músculo se destruye en forma masiva, como por ej., en la distrofia muscular y en el infarto cardíaco. En esos casos su determinación provee un dato específico y altamente sensible.

Distintos autores han intentado evaluar los cambios que se producen en la actividad de esta enzima en suero como consecuencia de factores nutricionales, pero los datos obtenidos no resultan coherentes y sus interpretaciones son contradictorias^{4,5,6}. Las discrepancias mencionadas podrían deberse a que las formas en que fueron expresados los resultados no son las más adecuadas para las características de una enzima que se está midiendo en un lugar diferente de aquél en el que cumple una función conocida.

El presente trabajo fue diseñado con el objeto de llevar a cabo un estudio sistemático de las variaciones de la actividad de CPK en suero en relación con la dieta, con un énfasis especial en la calidad de la información suministrada por las distintas formas en que los resultados de actividad enzimática pueden ser expresados.

Para realizarlo se utilizó un modelo experimental con ratas subnutridas realimentadas con dos tipos de dietas: de bajo contenido proteico y desequilibradas en su composición de aminoácidos. Trabajos anteriores utilizando estas dietas, demostraron que las mismas inducen alteraciones en los procesos de maduración tisular en las ratas que las ingieren; por ejemplo, se han observado cambios en la composición corporal⁷ y particularmente una disminución en la excreción de creatinina por efecto de las dietas desequilibradas⁸. Puede decirse que utilizando estos tipos de dietas se mimetizan algunas características bioquímicas presentes en los cuadros de malnutrición humana^{7,8,9} y presuntamente la actividad de la CPK podría verse modificada por la ingestión de este tipo de dietas.

MATERIALES Y METODOS

En todos los experimentos se usaron ratas de la cepa Wistar alimentadas "*ad libitum*" desde el destete (25 días). Los animales que ingirieron las dietas experimentales fueron llevados previamente a un estado de subnutrición, mediante el procedimiento de duplicación de la camada durante el período de lactancia¹⁰.

Paralelamente se utilizaron grupos controles constituidos por ratas normales (6 a 8 crías por madre) alimentadas durante el transcurso de la experiencia con la dieta stock¹ de nuestro vivero, que contiene 24,6 g % de proteína (N × 6,25) y 0,8 g % de lisina disponible.

Las ratas se alojaron en grupos de tres por jaula con fondo cribado. Los animales se sacrificaron a los 25 (tiempo 0), 40 y 60 días de edad por decapitación, después de un período de 4 horas de ayuno.

La actividad de CPK en suero se determinó siguiendo el método general de Hughes¹¹. Se expresó: 1) como actividad específica mmoles de creatina formada/mg de proteína sérica; 2) como mmoles de creatina formada/ml de suero; 3) como actividad total, mmoles de creatina formada por volumen sérico total del animal y 4) como actividad total/100 g de peso corporal de la rata.

Las proteínas séricas se determinaron por la reacción de Biruet según el método de Weichselbaum modificado por Dittebrandt¹², al solo efecto de expresar los resultados como actividad específica de la enzima. En lotes apareados por dieta, edad y peso, se llevaron a cabo las determinaciones de volumen plasmático según el método de L. Wang¹³, usando azul de Evans y bajo anestesia de uretano (1 g/kg de peso corporal).

Dietas

En el Cuadro 1 se detalla la composición de las dietas experimentales utilizadas, así como también el contenido en proteínas y en lisina disponible de las fuentes proteicas utilizadas: yema de huevo desgrasada, lactoalbúmina y gluten de trigo.

La dieta EY contenía yema de huevo desgrasada en cantidad suficiente para aportar 4,38 g % de proteínas y fue suplementada con L-lisina hasta una concentración de 0,4 g % de lisina disponible. La dieta LA contenía lactoalbúmina hasta una concentración de 4,00 g % de proteína y 0,2 g % de lisina disponible.

1. Forramez. Molinos Río de la Plata.

CUADRO 1
COMPOSICION DE LAS DIETAS

DIETAS	EY (g %)	LA (g %)	LG (g %)	YG (g %)
Yema de huevo desengrasada ¹	6.12	—	—	3.06
Lactoalbúmina ²	—	5.00	2.50	—
Gluten de trigo ³	—	—	13.90	13.90
L-lisina ⁴	0.18	—	—	0.09
Minerales ⁵	5.00	5.00	5.00	5.00
Mezcla de vitaminas ⁵	0.25	0.25	0.25	0.25
Clorhidrato de colina	0.15	0.15	0.15	0.15
Aceite de maíz	5.00	5.00	5.00	5.00
Dextrina	83.30	84.60	73.20	72.55
Lisina disponible total ⁶	0.40	0.20	0.30	0.40
Contenido de proteína total	4.38	4.00	11.50	11.75
Contenido de "proteína completa" ⁷	4.40	2.20	3.30	4.40
% de proteína completa con respecto a proteína total	100	55	29	37

1. Contiene 71.8% (N × 6.25) y 5.02 g % de lisina disponible.

2. Contiene 78.8% (N × 6.25) y 4.20 g % de lisina disponible.

3. Contiene 69.0% (N × 6.25) y 1.44 g % de lisina disponible.

4. Como Clorhidrato de L-lisina.

5. Según Harper, A. E. ¹⁷.

6. Se utilizan los valores de lisina disponible en lugar de los de lisina total, debido a la reacción de Maillard que se produce durante el proceso de obtención de yema de huevo desengrasada y del gluten de trigo. La disponibilidad de los otros aminoácidos no se ve alterada.

7. Según Munro y Allison ¹⁸.

La dieta *LG* contenía lactoalbúmina aportando 0,1 g % de lisina disponible y gluten de trigo, aportando 0,2 g % del mismo aminoácido con un contenido total de 11,50 g % de proteínas.

La dieta *YG* contenía yema de huevo desgrasada aportando 0,2 g % de lisina disponible y gluten de trigo aportando 0,2 g % del mismo aminoácido con un contenido total de 11,50 g % de proteínas. En las dietas *LG* e *YG* el desequilibrio se logró por el agregado de gluten de trigo cuya proteína es pobre en el aminoácido esencial lisina con respecto al contenido en los otros aminoácidos y se verificó de acuerdo al criterio de Río y Sanahuja por el método de las curvas de consumo¹⁴. La dieta *LG* se comportó como menos desequilibrada que la dieta *YG*, aun cuando el contenido de lisina y el porcentaje de proteína completa de la dieta *LG* fue menor que el de la dieta *YG*.

El contenido de nitrógeno se determinó por el método de Kjeldhal¹⁵ y la lisina disponible por el método de Carpenter modificado por Ragabendar Rao et al.¹⁶.

RESULTADOS Y DISCUSION

Efectos de las dietas experimentales sobre la ganancia de peso en los animales:

En la Figura 1 se muestran las curvas de crecimiento de los animales controles y experimentales; el aumento de peso de los animales que ingirieron las dietas en estudio fue significativamente menor ($p < 0,05$) que el de las ratas controles a lo largo de todo el período experimental.

Los grupos alimentados con las dietas *LG* e *YG* aumentaron significativamente más ($p < 0,01$) que los que ingirieron las dietas *LA* y *EY* respectivamente. Comparando el efecto producido por las dos últimas dietas nombradas, se observó que la dieta *EY* indujo un aumento de peso, mientras que la *LA* se comportó como dieta de mantenimiento, ya que el peso final de los animales no fue significativamente distinto del peso al destete.

Todas estas diferencias en la ganancia de peso se observaron independientemente de que en forma similar a experiencias previas⁷, el consumo total de las dietas no mostró diferencias significativas.

Efecto de las dietas experimentales sobre la actividad de CPK:

En clínica médica los cambios de actividad de CPK en suero se expresan habitualmente como unidades de producto formado

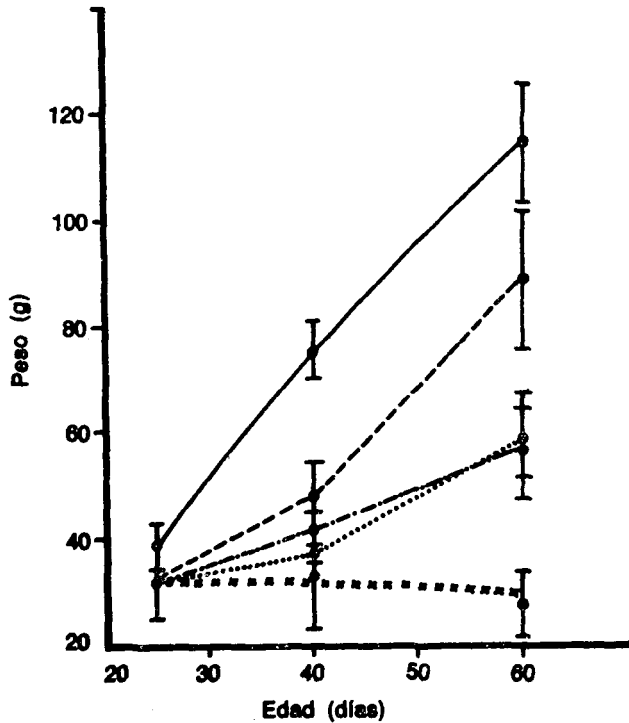


Figura 1. Curva de crecimiento de los animales alimentados con las dietas control (—) y experimentales: EY (-.-.-); LA (xxxxx); LG (.....) e YG (-----).

en la unidad de tiempo, por mg de proteína o por ml de suero. Estas formas de expresión resultan de utilidad en casos de destrucción de masa muscular en que los valores de CPK en suero aumentan en forma notable.

En las Figuras 2A y B se muestran los resultados obtenidos en este trabajo expresados en las formas antes mencionadas. En ellas se ve que ni el estado de subnutrición previo ni las dietas utilizadas indujeron cambios de magnitud en la actividad enzimática. Esto se debería a que no hubo en ningún caso destrucción masiva de tejido muscular, sino una pérdida paulatina de la masa muscular funcionante; esta pérdida se produciría concomitantemente con otras alteraciones fisiológicas y bioquímicas, tal el caso de los cambios de volumen plasmático que se han observado en los animales alimentados con las mismas dietas

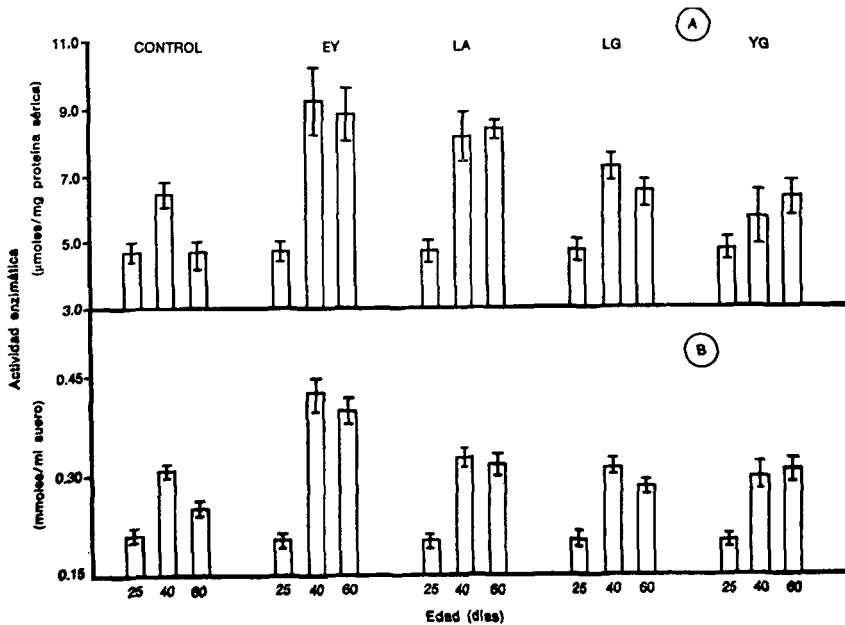


Figura 2. Actividad de CPK en suero de rata en función de la edad: A) μ moles de creatina/mg de proteína sérica; B) mmoles de creatina/ml de suero.

empleadas en este trabajo ¹⁹, así como también en otros casos de malnutrición experimental ²⁰ y humana ^{21, 12} que aparecen en la literatura.

Por esta razón es de interés ensayar la validez de la expresión como actividad total de CPK en suero, es decir teniendo en cuenta el volumen plasmático.

Los datos expresados como actividad total circulante en función de la edad y del peso así como los valores del volumen plasmático, se muestran en el Cuadro 2. Los resultados permiten detectar un marcado efecto de la subnutrición inicial sobre la actividad de la enzima, ya que los animales subnutridos presentaban a los 25 días de vida (tiempo 0) una actividad total significativamente menor ($p < 0,05$) que los respectivos controles. Además, en todos los animales que ingirieron las dietas experimentales los valores de CPK total fueron significativamente menores ($p < 0,05$) que los de los respectivos controles a cualquiera de las edades estudiadas.

CUADRO 2

EDAD, PESO, VOLUMEN PLASMÁTICO Y ACTIVIDAD TOTAL DE CPK DE LOS ANIMALES
CONTROLES Y EXPERIMENTALES

DIETAS	Edad (días)	Peso (g)	Volumen plasmático (ml)	Actividad total (mmoles)
Controles ²		1	1	1
Tiempo "0"	25	39.3 ± 4.5	2.96 ± 0.27	0.58 ± 0.03
	40	75.7 ± 5.2	4.76 ± 0.59	1.25 ± 0.08
	60	114.8 ± 10.8	6.24 ± 0.44	1.35 ± 0.07
Subnutridas				
Tiempo "0"	25	32.3 ± 7.0	2.05 ± 0.05 ^a	0.42 ± 0.02 ^a
EY (6.12% yema de huevo desengrasada + 0.18% lisina)	40	42.1 ± 3.6 ^a	1.66 ± 0.10 ^a	0.67 ± 0.10 ^a
	60	57.8 ± 6.8 ^a	1.24 ± 0.01 ^a	0.64 ± 0.07 ^a
LA (5.00% lactoalbúmina)	40	34.1 ± 11.0 ^a	1.24 ± 0.06 ^a	0.46 ± 0.05 ^a
	60	27.6 ± 6.1 ^a	1.26 ± 0.05 ^a	0.40 ± 0.02 ^a
LG (2.50% lactoalbúmina + 13.9% gluten de trigo)	40	37.8 ± 3.8 ^a	1.70 ± 0.09 ^{a b}	0.59 ± 0.03 ^a
	60	58.1 ± 10.4 ^{a b}	1.62 ± 0.07 ^{a b}	0.45 ± 0.04 ^{a c}
YG (3.06% yema de huevo desengrasada + 0.09% lisina + 13.9% gluten de trigo)	40	47.6 ± 7.5 ^a	1.68 ± 0.09 ^a	0.50 ± 0.06 ^a
	60	88.9 ± 13.0 ^{a d}	1.69 ± 0.06 ^{a d}	0.52 ± 0.06 ^a

1. Media ± Error estándar de la media.

2. Dieta stock de nuestro vivero: Forramez.

Significación estadística de las comparaciones pareadas analizadas por la prueba "t" de Student.

a. Diferencia significativa ($p < 0.05$) con respecto al control de la misma edad.

b. Diferencia significativa ($p < 0.001$) con respecto al lote LA de la misma edad.

c. Diferencia significativa ($p < 0.05$) con respecto al lote EY de la misma edad.

d. Diferencia significativa ($p < 0.01$) con respecto al lote EY de la misma edad.

En los animales que ingirieron la dieta control la actividad enzimática aumentó al aumentar el peso hasta alcanzar un valor que permaneció constante a partir de los 40 días de vida.

Los lotes alimentados con la dieta *EY* se apartaron de lo normal a partir de los 40 días de vida en que la actividad total no continuó ligada al incremento de peso. Los alimentados con la dieta de bajo contenido proteico *LA* se mantuvieron con una actividad relacionada al peso, por supuesto por debajo de lo normal para la edad. Los lotes que recibieron las dos dietas desequilibradas mostraron a los 40 días de vida, actividades que no fueron significativamente diferentes entre sí a pesar de la gran diferencia de peso observada, y muy por debajo de la actividad de las ratas normales del mismo peso. Además, pese a que a los 60 días de vida los lotes *EY* y *LG* tenían pesos similares, la actividad total de CPK circulante en el lote *LG* fue significativamente menor que en el *EY* ($p < 0,05$).

Estos resultados ponen de manifiesto la falta de correlación entre la actividad total de CPK y el peso de los animales experimentales; por lo tanto, se consideró oportuno eliminar la variable peso y expresar la actividad de CPK circulante por 100 g de peso corporal en función de la edad, como se muestra en la Figura 3.

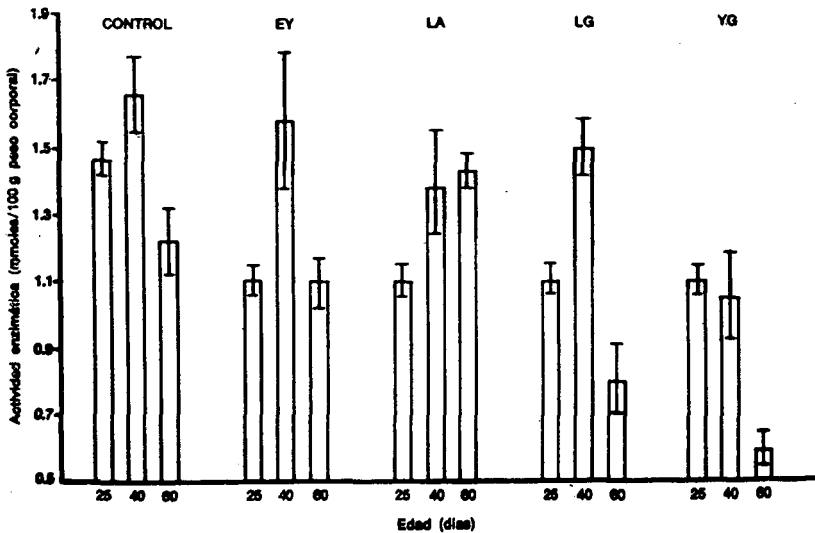


Figura 3. Actividad de CPK en suero de rata en función de la edad: nmoles totales/100 g de peso corporal.

Del análisis de esta figura se desprende que la disminución en la actividad de CPK observada en los animales subnutridos no sería atribuible únicamente al menor peso de los animales a los 25 días de vida, ya que al expresar los resultados a peso constante se mantuvieron las diferencias entre ambos lotes, control y subnutrido. Por otra parte, cuando se analizan los valores de la actividad de CPK en los distintos lotes se aprecian diferencias en los perfiles delineados por los extremos de las barras que no pueden explicarse mediante un análisis matemático sencillo. Esto podría deberse a la incidencia en el modelo experimental, de una serie de variables: dieta, edad, peso y estado nutricional previo. Ello hace necesario un análisis estadístico complejo de los datos obtenidos, que considere sus influencias individuales, así como también sus posibles interacciones.

Análisis estadístico:

La disposición de los datos es la de un diseño incompleto no ortogonal que puede analizarse mediante los parámetros del siguiente modelo lineal no aditivo y de efectos fijos:

$$Y_{ijk}^{(m)} = \mu^{(m)} + \alpha_i^{(m)} + \beta_j^{(m)} + (\alpha\beta)_{ij}^{(m)} + e_{ijk}^{(m)}, \text{ donde}$$

$$(1 \leq i \leq 3; 1 \leq j \leq 6; \phi \leq k \leq K_{ij})$$

que desglosa la "respuesta" (m -ésima forma de expresión $N^{\circ} m$ de la actividad enzimática) $Y_{ijk}^{(m)}$ correspondiente a la k -ésima rata de edad i que se somete a la dieta j . Esta descomposición contiene cuatro términos constantes y uno aleatorio; $Y^{(m)}$ se escribe como la suma de un nivel "basal" inespecífico $\mu_{ijk}^{(m)}$ que sólo depende de la respuesta $Y^{(m)}$; en un *efecto principal de la edad* $\alpha_i^{(m)}$; en un *efecto principal de la dieta* $\beta_j^{(m)}$; en un término de *interacción* $(\alpha\beta)_{ij}^{(m)}$ (que será distinto de cero si el efecto de la acción de uno de los factores depende de los niveles del factor restante) y en el término aleatorio $e_{ijk}^{(m)}$ normalmente distribuido, con una media nula y varianza Δ_m^2 constante para cada respuesta $Y^{(m)}$.

En nuestro experimento observamos la "respuesta" $Y^{(m)}$ (para $m=1$ en μ moles/mg de proteína, para $m=2$ en mmoles/ml de suero, para $m=3$ en mmoles totales y para $m=4$ en mmoles por 100 g de peso corporal de la rata) que cada unidad experimental produce ante una determinada combinación de los factores A (edad) y B (dieta). El primer factor tiene tres niveles (que

llamamos i ; para $i=1$ tenemos la edad del destete, para $i=2$ los 40 días y para $i=3$ los 60 días de vida), el segundo factor tiene cinco niveles (que llamaremos j ; para $j=1$ tendremos la dieta control Forramez, para $j=2$ la dieta *EY*; para $j=3$ la dieta *LA*; para $j=4$ la dieta *LG* y para $j=5$ la dieta *YG*) y en cada combinación particular (i, j) de niveles de ambos factores se recoge una cantidad variable $K_{ij}=0,4,5,6,7,8,10$ de observaciones.

Para detectar la significatividad de las diferencias entre los efectos principales de dieta y edad se utilizó el método de Scheffé²³, con coeficiente de confianza 0,95; las relaciones no explicadas no resultaron significativas al nivel $p<0,05$.

Se debe tener en cuenta que en este diseño estadístico los efectos de un factor se deben promediar sobre los niveles del otro cuando las interacciones de ambos no puedan despreciarse, y que la dieta stock se considerará como otra dieta experimental más, ya que su carácter de control es irrelevante para los propósitos del presente análisis.

Los resultados del análisis estadístico muestran que en cualquiera de las cuatro formas en que se expresaron los resultados, la actividad de CPK varió significativamente con la edad ($p<0,0005$). Promediando los datos obtenidos con todas las dietas, a la edad del destete las actividades fueron significativamente menores que a los 40 días de vida. Todas las formas de expresión de los resultados utilizadas muestran interacciones significativas entre edad y dieta ($p<0,0005$); esto implica que el modelo estadístico no puede considerarse aditivo en ningún caso y que no basta superponer un efecto de dieta a otro de edad para explicar las observaciones experimentales; por consiguiente, la acción de una dieta depende esencialmente de la edad y recíprocamente la actividad enzimática a una determinada edad depende de la dieta ingerida. Esta existencia de efectos recíprocos entre edad y dieta se manifiesta geoméricamente en la falta de paralelismo entre los cinco perfiles representados por los extremos de las barras que se muestran en las Figuras 2 y 3, correspondientes a las cinco dietas en estudio.

Con respecto a cada forma de expresión utilizada, el análisis dio los siguientes resultados:

- 1) y 2) *Expresión de actividad por mg de proteína y por ml de suero:* (Figura 2A y B)

Para cada dieta, los cambios de actividad enzimática expresados por mg de proteína o por ml de suero en función de la edad, fueron similares; en ambos casos la dieta *EY* provocó un cambio

en la actividad que fue significativamente mayor que los inducidos por las dietas control *LG* e *YG*, mientras que el efecto de la dieta *LA* resultó significativamente superior a los de las dietas control e *YG*.

Las inferencias que resultan del análisis de estas formas de expresión no son coherentes desde el punto de vista fisiológico, ya que indicarían que la actividad enzimática de los animales alimentados con las dietas desequilibradas se encuentran más cerca del comportamiento observado con la dieta control que la de los animales alimentados con las dietas de bajo contenido proteico. Este hecho se halla en contradicción con lo observado en trabajos previos^{7,8,9} donde se demostró que las dietas desequilibradas en aminoácidos producen alteraciones mucho más severas en la maduración tisular y cambios en la composición corporal de los animales que las ingieren.

3) *Expresión como actividad total:*

Esta forma de expresión de la actividad, como mmoles totales, exhibe diferencias entre los animales alimentados con cualquiera de las dietas experimentales y la dieta stock, aunque no permite discriminar entre dietas experimentales. Sin embargo, el análisis estadístico realizado sobre los datos obtenidos en las condiciones controladas de este experimento, permitió detectar diferencias significativas entre las respuestas a las dietas *EY* y *LA*.

Los datos obtenidos con los animales controles sugieren que la actividad total de CPK es proporcional a su masa muscular funcionante. Las diferencias de actividad observadas entre los animales controles y experimentales, estarían en concordancia con las diferencias previstas entre sus masas musculares. Los resultados obtenidos con los lotes experimentales indicarían que en ellos la masa muscular es semejante independientemente de la diferencia de peso.

4) *Expresión como actividad total/100g de peso corporal:*

Al estudiar el efecto de la edad, expresando los resultados a peso constante, observamos que esta forma de expresión fue la única que mostró diferencias significativas entre las actividades a los 40 y 60 días de vida, y además que, al promediar los datos obtenidos con cualquiera de las dietas la media al destete fue significativamente superior a la media obtenida a los 60 días de vida.

Al analizar los datos desde el punto de vista de la influencia de las dietas observamos que los efectos de la *EY*, *LA* y control

no fueron significativamente diferentes; además, estadísticamente se pudo discriminar entre el efecto de las dietas de bajo contenido proteico y la dieta YG, que es la más desequilibrada de las dos estudiadas.

Estas observaciones son concordantes con estudios anteriores de composición corporal⁹; las dietas de bajo contenido proteico tienen un efecto primario sobre el crecimiento, pero el proceso de maduración corporal no difiere significativamente del de los animales alimentados con la dieta stock, y esa sería la razón por la cual la actividad de CPK, expresada a peso constante, no difiere de la de aquéllos. En cambio, los animales que ingieren dietas desequilibradas crecen sin que la relación N/H₂O de su tejido muscular siga los patrones normales de maduración y ello se exterioriza mediante la disminución de la excreción de creatinina cuando se la expresa por unidad de peso. Trabajos previos⁸ demostraron que en los animales que ingirieron la dieta YG la creatinina urinaria disminuye de 37,0 mg/kg de peso al destete, a 19,0 mg/kg de peso a los 45 días de vida, siendo este comportamiento similar al observado en la actividad de CPK por 100 g de peso corporal.

Esta última forma de expresión, por lo tanto, sería la de mayor capacidad de discriminación en la comparación mutua de dietas experimentales.

Conclusiones

Haciendo una comparación de la información aportada por cada una de las cuatro formas de expresión analizadas en este trabajo, resulta evidente. a) que cuando se expresa la actividad de CPK por mg de proteína y/o por ml de suero, no guarda concordancia con los fenómenos fisiológicos inducidos por la ingestión de las dietas experimentales. Valores absolutos de actividad bajos o altos, no indican ni estado nutricional deficitario ni recuperación del mismo, porque la actividad enzimática no es sólo dependiente del grado de nutrición sino también de la edad y además porque edad y dietas presentan interacciones significativas. Por lo tanto, aun conocidas todas las variables que afectan la actividad de la CPK en suero, resultaría imposible interpretar una determinación individual. De esto se deduce que ninguna de estas expresiones es la adecuada cuando se pretende utilizar esta enzima para evaluar estados nutricionales. Estos resultados confirmarían la hipótesis previa de que la incoherencia de los datos existentes en la literatura deriva de que

éstas son las formas en que habitualmente se los expresa.

b) que cuando se expresan los datos como actividad total en suero, es posible distinguir el efecto de la malnutrición pero no los grados de la misma. Conocida la volemia, esta forma de expresión tal vez permitiría el seguimiento longitudinal durante la recuperación si se contara con los estándares normales. Sin embargo, no aportaría otra información que la que surgiría de la evaluación antropométrica o de la determinación de otros índices bioquímicos de más fácil realización como, por ejemplo, el "Índice creatinina/talla"³.

c) que la expresión a peso constante, que demostró ser la más adecuada bajo condiciones experimentales, quedaría limitada a este campo, ya que para su interpretación también sería necesario conocer el volumen plasmático, la edad, el peso real no afectado por cuadros de desequilibrio hídrico, así como la historia previa del paciente.

La información aportada por este modelo experimental nos permite concluir que la determinación de CPK en suero no presenta valor real para la detección y evaluación de la malnutrición humana, aun cuando bajo condiciones muy controladas puede proporcionar información sobre la masa muscular funcionante de los animales de experimentación.

SUMMARY

"SERUM CREATIN-PHOSPHOKINASE ACTIVITY: ANALYSIS OF INFORMATION PROVIDED BY DIFFERENT WAYS OF EXPRESSING THE DATA"

An experimental model with undernourished rats fed experimental diets containing either imbalanced proteins or low amount of well balanced proteins was used to evaluate the utility of serum CPK activity determination in human malnutrition. Special attention was given on the information provided by four ways of expression of the enzymatic activity. CPK activity was expressed as: 1) Specific activity, 2) Activity per ml serum, 3) Total activity per rat and 4) Total activity per 100 g body weight. Statistical analysis showed: a) Activity expressed per mg serum protein or per ml serum did not agree with the known physiological phenomena induced on muscle by the experimental diets: CPK activity values expressed in these ways are not useful in malnutrition studies. b) Serum total activity of CPK per rat provides a similar information to the creatinin/height index, which is easier to perform. c) Total CPK activity per 100 g body weight demonstrated to be adequate to provide information about muscle mass in rats under controlled experimental conditions. However, it is not possible to use this form of expressing CPK activity in human malnutrition, because it would be also necessary to know: plasma volumen, age, actual body weight, clinical and the nutritional background, etc., of the patient for an accurate interpretation of results.

AGRADECIMIENTO

Los autores agradecen al Lic. Armando Infante el asesoramiento y el estudio estadístico de los datos presentados en este trabajo.

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SYSTEMS ANALYSIS IN NUTRITION AND HEALTH PLANNING: APPROXIMATE MODEL RELATING BIRTH WEIGHT AND AGE TO RISK OF DEFICIENT GROWTH

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SUMMARY

This paper summarizes the initial phase of an effort to develop semiquantitative methods for nutrition and health planning. The general approach is to utilize the methods of systems analysis and operations research where appropriate, but the emphasis is on developing a simplified, approximate analysis that government planning groups could conveniently apply in evaluating various potential programs for attaining specific nutrition and health objectives, while satisfying certain constraints (e.g., budget, facilities, personnel).

An essential element of the analysis is a model that provides an approximate description of malnutrition (inadequate growth, as indicated by weight for age) and mortality in terms of those variables that can be affected by

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- INCAP Publication I-828.

Recibido: 1-7-1975.

intervention programs. We have concentrated initially on using the results of two INCAP longitudinal studies to develop models relating the incidence of malnutrition (second and third degree on the Gómez scale) to age and previous growth, including birth weight. The two studies cover rural Guatemalan communities with considerable variability in ethnic, socioeconomic, and ecological conditions. Because they are tentative, the resulting models are discussed only qualitatively and not quantitatively.

The models may serve as baselines to estimate the consequences of potential programs aimed at different target groups, such as pregnant women and children whose weights at birth or thereafter fall below prescribed levels. The possible benefits of using models of this nature in nutrition and health planning are discussed.

INTRODUCTION

Within the developing countries there is an increasing recognition of the need for health planning methodologies that are more systematic and more quantitative than those now employed^{1, 2}. Improved methodologies are essential to insure that planning groups will be able to utilize more effectively the limited resources that are available for raising the health status of the population. But health planning is an extremely complex process involving many possible goals and variables, a wide variety of potential programs, interrelations with other sectors (e.g., agriculture, education, economics), political considerations, and cultural factors.

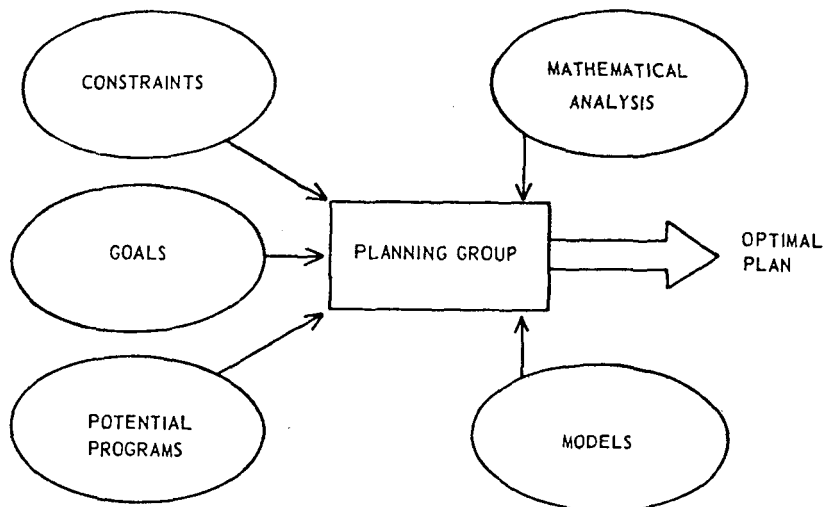
There have been several attempts to develop detailed mathematical methodologies^{6 (3)}. These generally are too complicated for most planners, and they usually require data that are unavailable and extremely costly to obtain. This severely restricts their usefulness to the health planner of a developing country. On the other hand, even the critics of these analyses would agree that some steps must be taken to develop a more quantitative planning methodology.

The long-range objective of our project is to develop a health planning methodology that is sufficiently simple to be readily understood and applied by planners, while at the same time being sufficiently detailed to provide useful semiquantitative results for guiding the selection of the most effective programs. Although we propose to employ the concepts and techniques of

6. For references to these attempts, see p. 105 of Hilleboe *et al.*²; also see articles in PAHO⁴.

systems analysis⁷ where appropriate, the primary emphasis is on simplicity. As a consequence of this emphasis, we realize that the resulting methodology will not be completely comprehensive or highly accurate; however, it will hopefully include many of the most important aspects of the problem.

We suggest that the planning process may be described conveniently in terms of the components shown in Fig. 1:



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Fig. 1

Schematic diagram of the principal components of a planning process.

1. *Goals.* It is generally agreed that a planning group cannot proceed without having a clearly-defined set of goals, described in quantitative terms and to be reached in a given period of time (e.g., to reduce infant mortality by 50% within 10 years)⁵. These goals are selected at a higher government level, but it is the planners responsibility to see that the goals are reasonable and clearly defined. The definition of quantitative goals is at the same time the very first decision to be taken in the process of health planning, and the most important one.

7. The term "systems analysis" is used here in its most general sense; i.e., it includes operations research, simulation techniques, decision analysis, econometrics, and mathematical optimization methods.

One of the roles of the planner—and of the analyst—is to provide adequate information to assist the political decision-maker in making the best choice of goals.

2. *Constraints.* The possible means for attaining these goals are restricted by various constraints, such as those relating to availability of resources (funds, facilities, trained personnel, supplies) and availability of adequate technologies, as well as constraints relating to political and cultural factors. These constraints are classically separated into “intra-sectorial constraints”, i.e., those within the health system, and “extrasectorial” ones. The planner must decide which constraints are most important and how they can be included in the decision process, either explicitly or implicitly.

3. *Potential Programs.* Since there are a vast number of potential programs that could be considered as possible candidates for attaining the prescribed goals, the group must limit its considerations to a reasonable number of programs. This elimination process is influenced by the nature of the goals and the constraints, and also requires the group to make qualitative estimates of which programs appear to be most promising.

The three components commented upon so far (goals, constraints, and potential programs) can be expressed in terms of variables which, in principle, can be interconnected by means of equations representing their mutual interplay. This is the role of the other two components of Fig. 1 (models and mathematical analysis).

4. *Models.* In order to compare the relative attributes of the various potential programs, the planners must be able to estimate the expected performance of each program (i.e., the level of contribution of each program to the prescribed goals for different levels of inputs of resources). These estimates require the development of “models”, i.e., approximate mathematical descriptions, of: (a) the dependence of the outputs of a program on the inputs (investments of resources); and (b) the influence of these programs outputs (e.g., lower risk of malnutrition) on the prescribed goals (e.g., reduce infant mortality by 50% within 10 years).

5. *Mathematical Analysis.* A principal objective of the planner is to design an “optimal plan”, i.e., a specific combination of programs that has the highest probability of meeting the prescribed goals, while minimizing expenditures of the most scarce resources and also being consistent with the other constraints. Generally, this design step is most conveniently accomplished with a mathematical analysis that interrelates the

models, goals, and constraints in terms of an evaluation parameter that may involve costs, effectiveness, efficiency, number of persons affected, or other measures of performance. The analysis might be linear programming or a simulation method. Clearly, the practical implementation of the analysis would be greatly facilitated if analytical results for a wide range of variables could be presented in terms of generalized graphs and tables, thereby minimizing the necessity of complex computations by the planner.

Although it might appear from this description that each of these five components should be considered separately in the order given above, this would not be the most effective approach in an actual planning process. Instead, some aspects of the components should be considered simultaneously because of strong interrelationships (e.g., constraints and mathematical analysis); furthermore, we expect that the planning group will decide to modify the initial details of the components after other components are developed and a more accurate view of the overall problem evolves.

In previous studies we have considered various aspects of the application of systems analysis to the planning of nutrition-related programs in developing countries⁶⁻⁸. One of our recent studies⁹ illustrates how a simple model of malnutrition and mortality for children below 4 years of age could be utilized in an approximate analysis of the expected consequences of nutrition intervention programs. This preliminary illustration motivated the present study to develop a more satisfactory model of malnutrition, i.e., of inadequate growth as expressed by the weight of children at various ages. Specifically, we have attempted to develop models that would help the planner to see more clearly the consequences of intervention programs that affect the growth of children in different age intervals (including the prenatal period) or that are restricted to children with low birth weight. The models are based on available results of detailed long-term prospective (longitudinal) studies conducted by INCAP¹⁰⁻¹² in rural Guatemala. For thorough discussions of these data, publications by Mata *et al.*^{10, 11} and Lechtig *et al.*¹² may be consulted. In the present paper we concentrate on the modeling procedures and several illustrative applications, since the models are not yet sufficiently refined to warrant detailed interpretation and application.

Although malnutrition is only one of the many health problems encountered in developing countries, it is considered to be among the most important and serious problems for children

during the first two or three years of life¹³. We expect that the modeling procedures developed for malnutrition will prove to be useful in studies of other health problems.

DESCRIPTION OF MALNUTRITION MODEL

The primary purpose of the models in this study is to illustrate the potential usefulness of such models in the planning of programs for improving the growth of preschool children. With this purpose defined, the next step is to determine what choice of variables appears to be most meaningful.

Dependent Variables

One of the most widely accepted indicators of inadequate growth of preschool children is the Gómez classification of the prevalence of malnutrition¹⁴. The PAHO Interamerican Study of Mortality in Infancy and Childhood¹³ has shown that children in specific age intervals whose weight falls below 75% of the mean weight of children of the same age and sex in an economically advanced area (i.e., children in the second or third degree of malnutrition according to the Gómez classification) have higher risk of death than those with adequate growth. It is recognized that growth depends on morbidity as well as on diet, but is relatively independent of genetic differences in the first few years of life¹⁵.

We shall adopt the percentage of children with weight below 75% of the standard as a dependent variable of the model although it has certain deficiencies, especially for children over 2 years of age¹⁶. The mean weights of children in Denver¹⁷ will be used as the standard because of the large size of the sample and the convenient form of the published data.

The prevalence of babies with low birth weights (≤ 2.5 kg) will be adopted as the second dependent variable because of its proven value as an indicator of unfavorable prenatal conditions that result in higher risks of malnutrition, morbidity, and mortality in the postnatal period¹¹. Low birth weight is an indicator of fetal malnutrition resulting from inadequate health and nutrition of the mother before and during pregnancy^{11, 12}; it is recognized that there are many non-nutritional problems that can also lead to low birth weight¹⁸.

Deaths were not included as dependent variables because it would have complicated considerably a model aimed mainly for

illustration, and also because the data available do not include a sufficient number of deaths to allow for safe conclusions. In a previous study, however, we have described a very approximate way of including this factor⁹, and we plan to develop an improved mortality model that may be combined with the present model to remove this limitation.

Independent Variables

Selection of the independent variables is extremely difficult because there are so many factors that strongly influence the dependent variables (prevalence of malnutrition and low birth weight), and many of these factors can be changed by intervention programs. At present, the data available are not sufficient for adopting independent variables relating to the detailed causes of malnutrition (e.g., duration of breast feeding, nutrient content of supplemental diets, incidence of infectious diseases, social stimulation). Therefore, we will adopt the following gross variables: (1) risk of low birth weight; i.e., the probability of an infant having a birth weight of 2.5 kg or less; (2) risk of malnutrition in any age interval; i.e., the probability of a child's weight falling below the prescribed "malnutrition level" during a specific age interval; and (3) the probability of recovery; i.e., the probability of a child's weight rising above the prescribed "malnutrition level" during the age interval considered. As will be described later, the magnitude of each of these variables may be changed by various types of intervention programs.

Structure of Model

The choice of variables suggests that the structure of the model should include the following characteristics: (1) two classes of children, one with birth weights of 2.5 kg or less (the "low birth weight class", denoted by LBW), and the other with birth weights above 2.5 kg (the "acceptable birth weight class", denoted ABW); (2) two nutritional states of the children in each age interval, one corresponding to weights equal to or below the 75% level of the reference population (the "malnutrition state", denoted by M), and the other to weights above this 75% level (the "acceptable nutritional state", denoted A); (3) several age intervals within the period 0 to 2 years of age.

The model is based on these characteristics together with the following simplifying assumptions:

1. The nutritional status of a child at a particular age depends only on the child's birth weight class (LBW or ABW) and

nutritional status at the immediately-preceding age (i.e., not on the child's nutritional status at any earlier ages). This is the assumption of a Markov process¹⁹, and it greatly simplified the model by having only two nutrition states in each age interval, rather than numerous states corresponding to different histories (sequences of previous nutritional states). We are unable to test the validity of this assumption with the available data because there are not enough cases in many of the different histories.

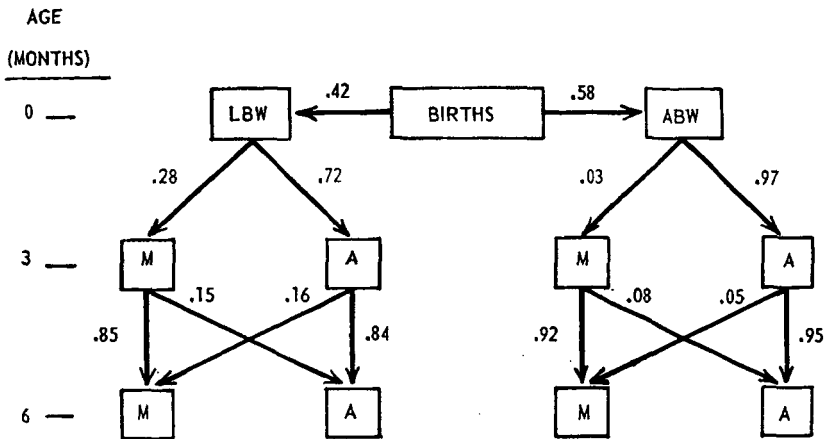
2. The removal of children from the model due to deaths is being neglected at this moment, as already mentioned.

The mathematical development of the model is presented in the Annex. For the sake of illustration, and in order to avoid the use of mathematical symbols, we will use actual figures based upon the INCAP studies.

MODEL OF GUATEMALAN INDIAN VILLAGE

During the past 10 years INCAP has conducted a detailed longitudinal study of the growth and health of young children in a Guatemalan highland community, Santa María Cauqué. The data indicate that the birth weights and subsequent growth of the children are extremely poor, and morbidity, especially diarrheal diseases, is severe. Consequently, the infant mortality rate is high, being about 100 per 1,000 births. (For a more detailed description of the nature of the community, the study, and the data, see Mata *et al.* 1967 and 1974^{10, 11}).

We have analyzed the data for Santa María Cauqué to obtain estimates of the independent variables of the malnutrition model. As of February, 1972, there were 438 children with birth weights recorded, and 185 of these had low birth weights. Therefore, the risk of low birth weight is $185/438=0.42$, while the probability of having acceptable birth weights is 0.58. (See Fig. 2). The number of LBW infants having data available on their weights at 3 months of age is 145, and 40 of these have weights that classify them as being malnourished. Consequently, the corresponding risk of malnutrition is, in this case, $40/145=0.28$. The chance that a LBW infant will have an acceptable nutritional status at age 3 months is therefore 0.72. The corresponding probabilities for children born with an acceptable weight (ABW) were found to be 0.03 and 0.97, respectively. As can be seen, the probabilities of being malnourished at 3 months vary widely according to the birth weight.



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Fig. 2

Malnutrition model (0 to 6 months) with variables evaluated from the longitudinal data for Santa María Cauqué.

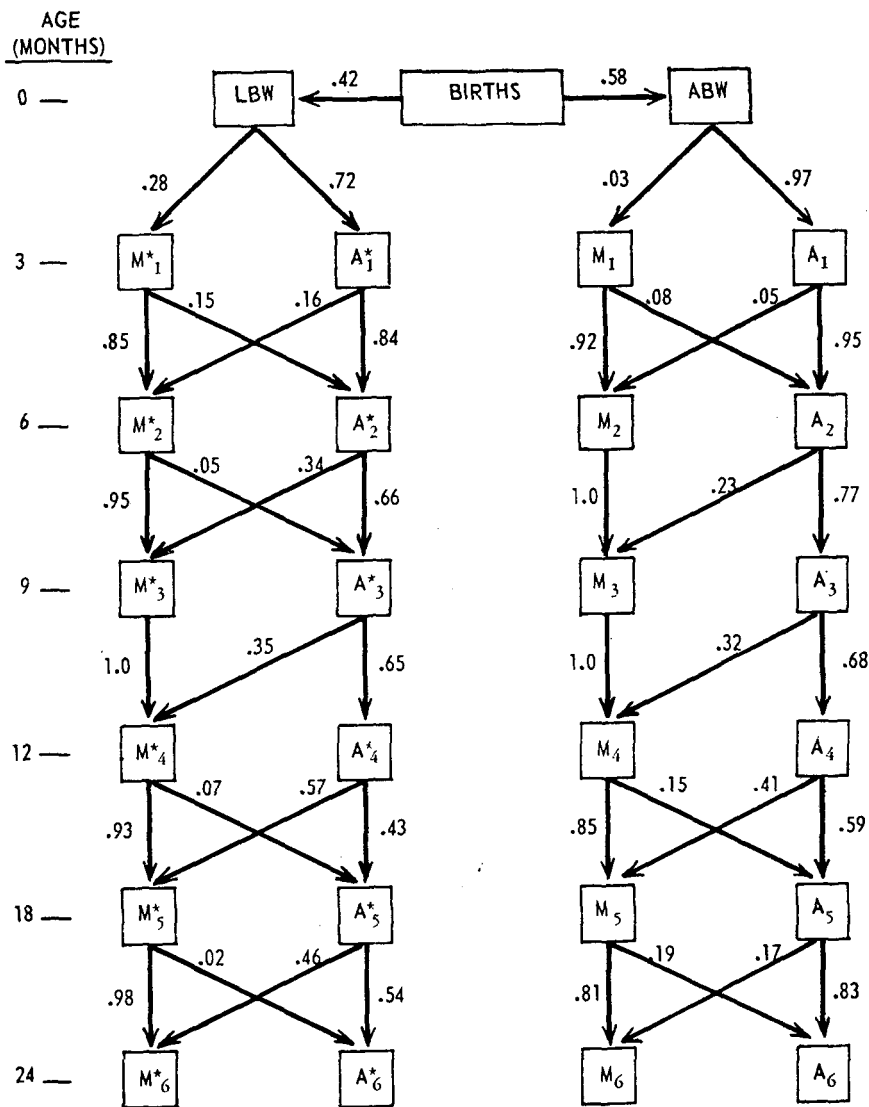
Some of the LBW children who are malnourished at 3 months will recover and attain acceptable nutritional status at 6 months (0.15 of them, while 0.85 will remain malnourished). Similarly, 0.16 of the children with LBW who are adequately nourished at 3 months will be found malnourished at 6 months. The corresponding figures for the children born with an acceptable weight are 0.08, 0.92, 0.05, and 0.95, respectively, as shown in Fig. 2.

The same is obtained for all other age intervals (see Fig. 3 for the fully developed model for Santa María Cauqué). The final result is that we have a sufficient set of equations to calculate the dependent variables (prevalence of malnutrition at various ages, and the prevalence of low birth weight children) if the values of the independent variables are known.

The two birth weight models (LBW and ABW) shown in Fig. 3 can be combined into one malnutrition model. The result is presented in Fig. 4.

MODEL OF LADINO COMMUNITIES

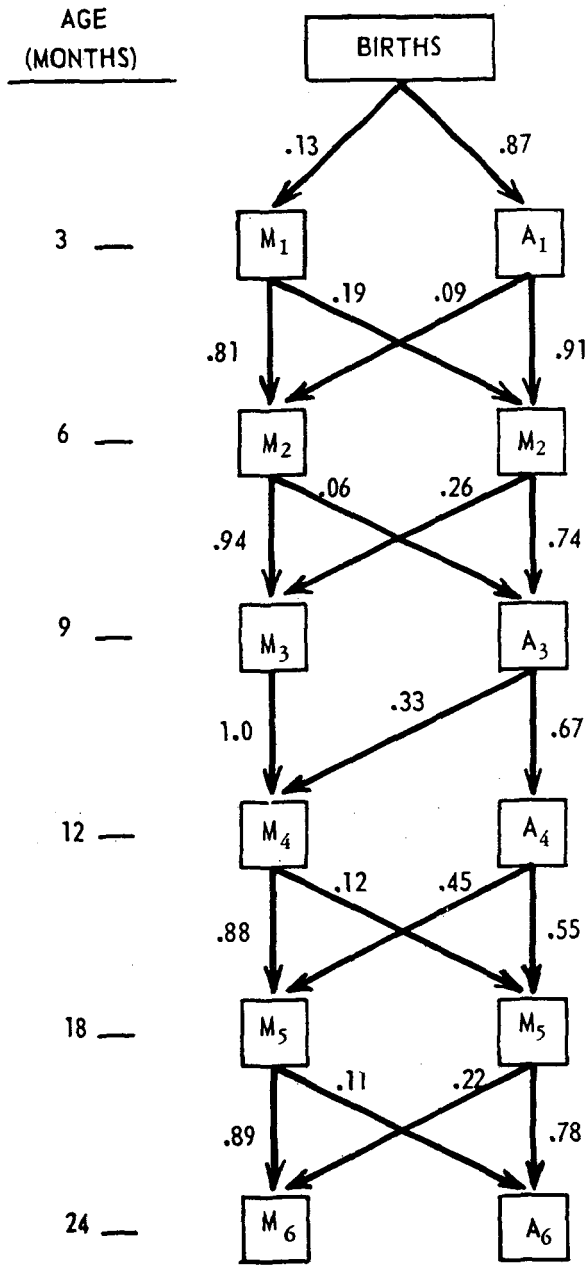
INCAP also is conducting a longitudinal study of four rural Guatemalan communities¹² in which the people are predomi-



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Fig. 3

Malnutrition model (0 to 24 months) with the variables evaluated from the longitudinal data for Santa María Cauqué.



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Fig. 4

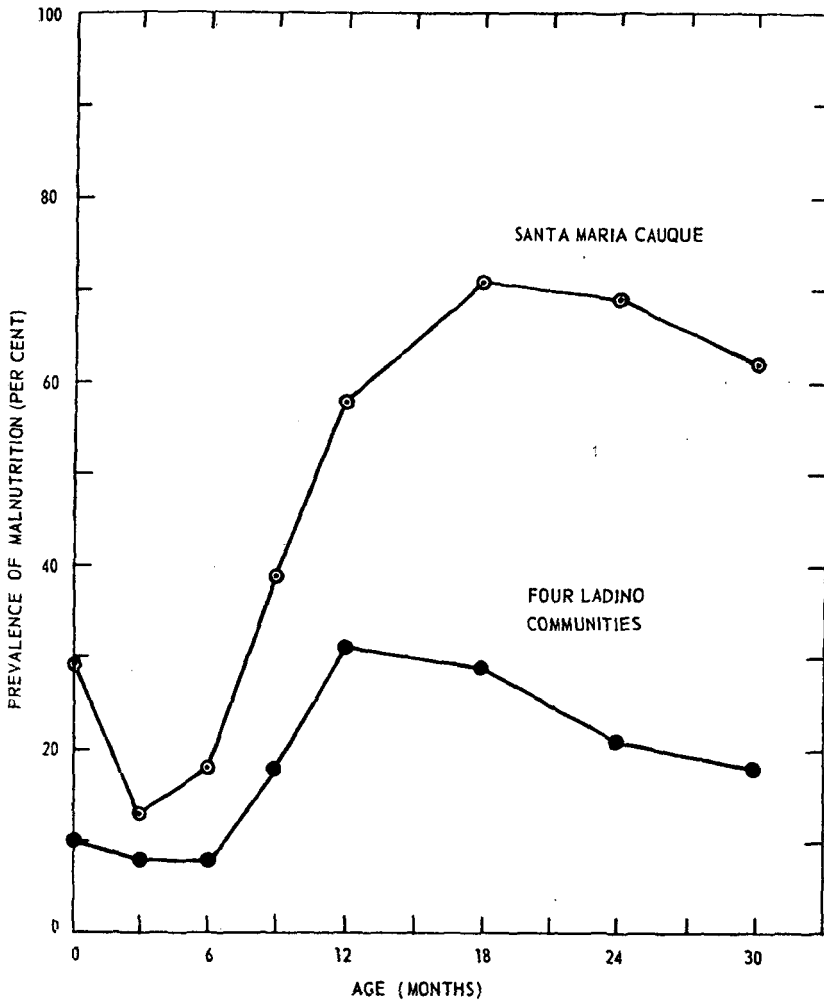
Malnutrition model formed by combining the two birth weight models shown in Fig. 3.

nantly "ladinos", that is, people who do not use Indian dress and languages and do not follow Indian traditions. These communities provide a valuable contrast to Santa María Cauqué because their socioeconomic condition is higher, with the consequences being much lower prevalences of low birth weight babies (0.14 vs. 0.42) and of malnutrition (0.21 vs. 0.69 at age 2 years), plus a lower infant mortality rate (approximately 50/1,000 vs. 100/1,000 live births). Because of these differences between the ladino and Indian communities, it is expected that the respective models for these communities will aid in developing a more general model that, with minor adjustments based on cross-sectional data, will provide an approximate description of communities for which such detailed data are not available. A general model of this nature would be valuable in government planning efforts in which a variety of communities are considered. Although we have not yet attempted to formulate a general model, we are encouraged by the observation that the dependence of prevalence of malnutrition on age is qualitatively similar for the ladino and Indian communities (Fig. 5), although there are substantial quantitative differences. This observation suggests that it may be possible to formulate a general model in terms of several "similarity parameters" that could be evaluated for any community in terms of data that are either presently available or readily measured.

In the longitudinal study of the ladino communities, several different interventions have been implemented and monitored²⁰. Consequently, the longitudinal data are a potential basis for developing models of these interventions. As a first step, we have concentrated on modeling only the intervention of reducing the prevalence of low birth weight babies by means of a caloric supplement to women during pregnancy. Since the details of this intervention are described and analyzed in previous publications¹², we will go directly to the preliminary model in Fig. 6 that has been developed by a procedure similar to that described in Section 3 and in the Annex. At present, this model extends only to 6 months of age because other interventions complicate the situation after that point.

The pregnant women are, for reasons explained elsewhere¹², divided into two groups:

- AS ("acceptable supplementation") = women who have consumed 20,000 or more supplementary calories during pregnancy
- IS ("inadequate supplementation") = women who have consumed less than 10,000 supplementary calories during pregnancy



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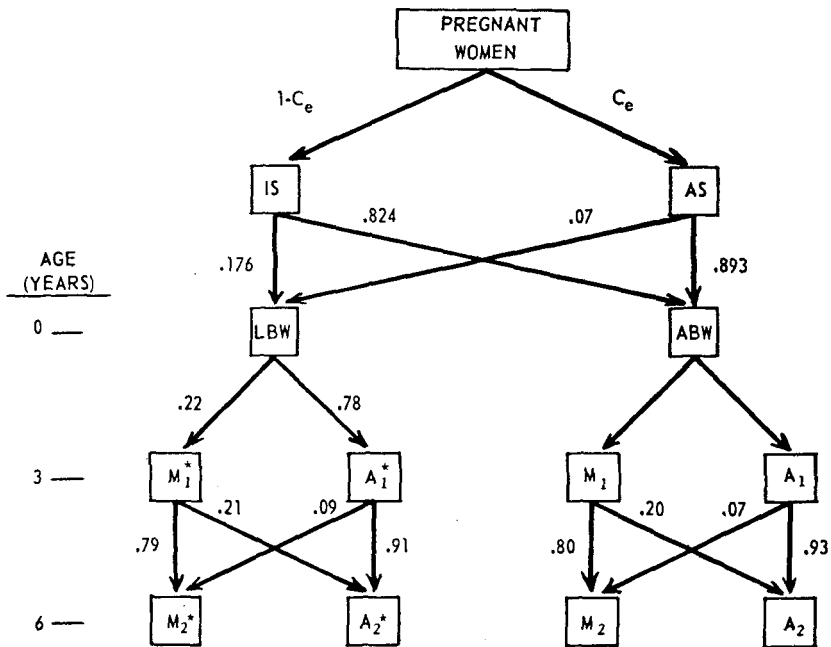
Fig. 5

Comparison of the age dependence of the prevalence of malnutrition in ladino and Indian Guatemalan communities.

The IS group is taken as the reference group, since their average consumption of supplement is sufficiently low to be essentially negligible relative to that of the AS group. The variable C_e in Fig. 6 represents the effective coverage of the supplement-

tation program, i.e., it is defined as the fraction of pregnant women who consume 20,000 or more supplementary calories.

As may be seen in Fig. 6, the effect of the supplementation program is to reduce the risk of low birth weight from 0.176 to 0.107. Although the intervention produces a substantial change in birth weight, analysis of the existing longitudinal data indicates that supplementation during pregnancy does not have a statistically significant effect on the postnatal growth of children of comparable birth weights during the first 6 months. This result is consistent with the assumption of a Markov process described previously, and it allows us to disregard the supplementation category of children's mothers after birth weight has been determined. This represents a considerable simplification



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Fig. 6

Malnutrition model with variables evaluated from longitudinal data for ladino communities in Guatemala. Included is an intervention that provides a fraction (C_e) of the pregnant women with 20,000 or more supplementary calories during pregnancy. AS: 20,000 Cal. IS: 10,000 Cal.

in the model, since it would be necessary to have four states at birth (i.e., LBW + IS, LBW + AS, ABW + IS, ABW + AS) if there were a significant dependence of postnatal growth on supplementation during pregnancy.

Although the model in Fig. 6 is very preliminary, it does serve as an example of the possible role of modeling in nutrition planning. Specifically, with a model of this type it would be possible to compute the prevalence of low birth weight and the prevalences of malnutrition at 3 and 6 months of age for different levels of effective coverage, C_e . These results, together with an estimate of the dependence of the cost of the program on the level of C_e , would enable a planning group to perform a cost-benefit or cost-effectiveness analysis of the intervention.

ILLUSTRATIVE APPLICATION OF MODEL

We now consider an oversimplified illustration of the potential use of malnutrition models in health planning efforts. Although numerical values will be used in this illustration in order to prevent it from being too abstract, these values should not be considered to be accurate or realistic since the present model ignores several important factors, such as the loss of children by deaths.

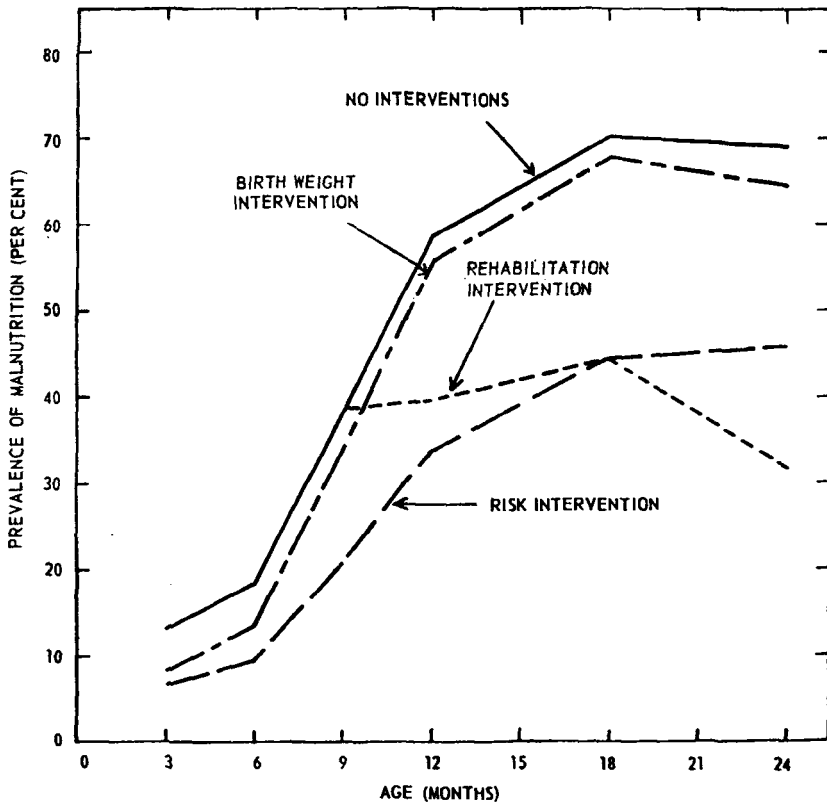
Consider a hypothetical situation in which a planning group is attempting to compare the relative benefits of the following three potential intervention programs for a population similar to that of Santa María Cauqué.

1. *Birth Weight Intervention* that reduces the risk of low birth weights by 50%, i.e., from 0.42 to 0.21, without influencing significantly the values of any other variables in the model (Fig. 2). A supplemental feeding program for pregnant women is a possible example of this type of intervention¹², although we would expect that it might also affect the values of other variables in the model.

2. *Risk Intervention* in which the risk of becoming malnourished is reduced by 50% for children between 0 and 24 months of age, while the chances of becoming or remaining well nourished are increased correspondingly as described in the Annex. Possible examples of the type of intervention are programs that reduce diarrheal disease (e.g., improved water supply) or that improve the weaning diet (e.g., nutrition education, supplementary feeding). However, for both examples we would expect that there might also be changes in other variables, such as the recovery probabilities.

3. *Rehabilitation Intervention* that results in the recovery of 50% of those malnourished children who would have otherwise continued to be malnourished in the particular age interval. An example of this type of intervention is feeding plus nutrition education through nutrition rehabilitation centers²¹, but we expect that such a program might also affect the risk of malnutrition. Since these centers usually do not accept children below 9 months of age, we will only consider the intervals between 9 and 24 months.

The results shown in Fig. 7 were calculated by modifying the models in Figs. 3 and 4 in the manner described above. The



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Fig. 7

Illustration of the effects of three hypothetical interventions on the prevalence of malnutrition for 0 to 2-year-old children. (Calculations based on the preliminary model of Santa Maria Cauqué).

average prevalence of malnutrition for a particular intervention is proportional to the area under the corresponding curve in the age range being considered. By measuring these areas, we have calculated the degree to which each intervention reduces the prevalence of malnutrition. The results are presented in Table 1

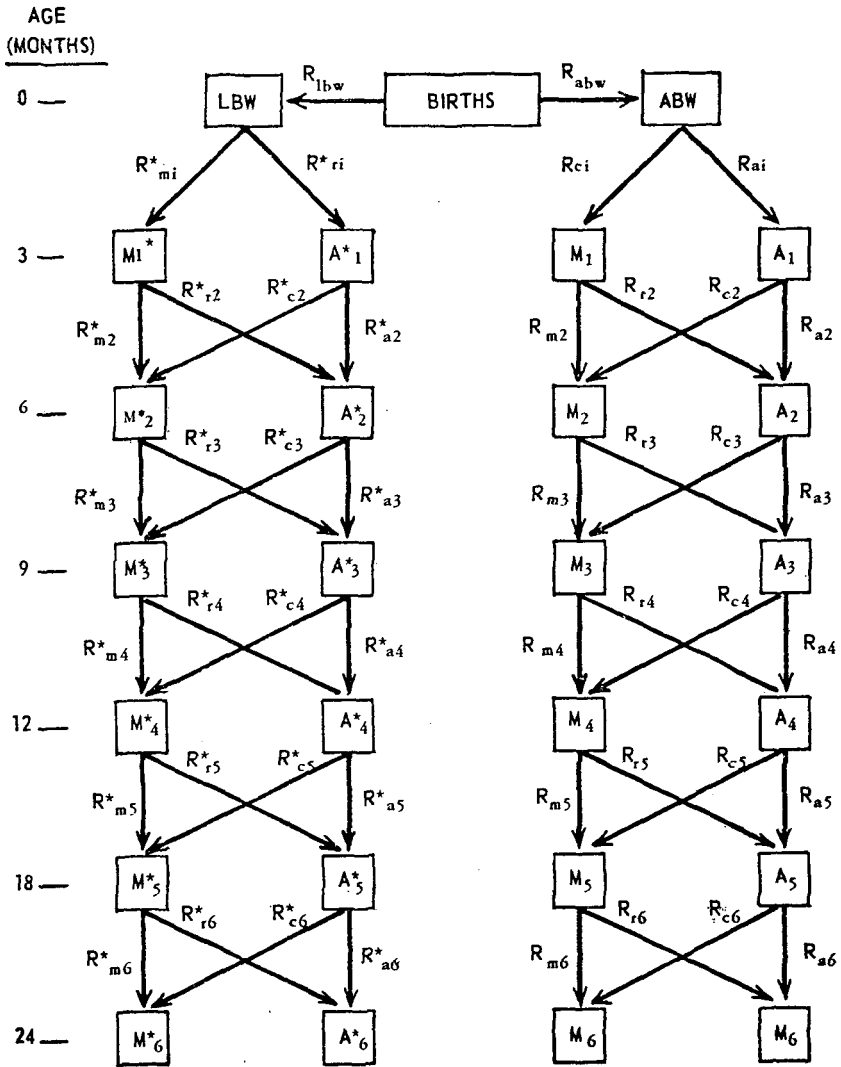
TABLE I
REDUCTION OF THE PREVALENCE OF MALNUTRITION
BY THREE HYPOTHETICAL INTERVENTION PROGRAMS

Type of intervention	Percent reduction of malnutrition for three age ranges		
	3 to 12 months	12 to 24 months	3 to 24 months
Birth weight	14	5	7
Risk of malnutrition	46	37	39
Rehabilitation	10	40	32

for three age ranges: 3 to 12 months, 12 to 24 months, and 3 to 24 months. Results of this type would be useful to a planning group because they indicate the relative benefits of the potential interventions in different ranges of age. We will not attempt to draw definite conclusions from these results, since they are based upon a very preliminary model and therefore serve only to illustrate the procedure. Furthermore, a meaningful comparison of the interventions would require that we include program costs in the calculation to obtain results in terms of a cost-benefit or cost-effectiveness ratio. An additional need is to include mortality in the model so as to be able to compare the interventions on the basis of both malnutrition and mortality; in this case, the true value of the birth weight intervention would be more apparent.

DISCUSSION AND CONCLUSIONS

This preliminary study describes a possible method for developing simple models for health planners. In the particular case considered, a tentative model was developed of the dependence of the risk of malnutrition on birth weight and on age of children below two years of age.



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Fig. 8

Malnutrition model for children with low birth weight (LBW) and acceptable birth weight (ABW).

Although the quantitative details of the models are not expected to be highly accurate, we believe that the study serves to illustrate several points:

1. Models of this type can provide a clear view of the epidemiology of malnutrition in the population under consideration. For example, the present results for Santa María Cauqué clearly show: (a) the important role of low birth weight¹¹; (b) the relatively high probability of low birth weight babies attaining acceptable weights by 3 months of age^{8 (10)}; (c) the high risk of malnutrition for children between 6 and 18 months of age, independent of whether or not they had low birth weights.

2. In a very preliminary manner we have illustrated how the models may be used by health planners to evaluate, on a semi-quantitative basis, the relative benefits of different potential interventions.

3. Data obtained through long-term prospective studies are extremely important to the development of planning models.

We believe that attempts to develop simple models will lead to more effective communication between research groups and planners by indicating which factors are most influential. A likely consequence is that such attempts will provide a useful feedback that will guide future research efforts by indicating the type of the information that is most essential to planning.

Our future plans are to refine these models by more thorough analysis of a larger collection of data, and to attempt to develop a general model that can be applied to communities for which longitudinal data do not exist. We also plan to include an approximate model of the dependence of child mortality on malnutrition. The combined model of malnutrition and mortality would then be utilized in an analysis involving cost-benefit or cost-effectiveness ratios. A final step would be to test the utility and accuracy of the models by applying them in a real situation that begins with selection of interventions and continues through the final evaluation of the performance of these interventions.

8. To a small extent this high recovery probability is influenced by the fact that, for the Denver standard used herein, the definition of low birth weight (≤ 2.5 kg) is more severe than the definition of malnutrition. Specifically, 2.5 kg corresponds to 78% of the Denver mean birth weight, rather than 75%.

ACKNOWLEDGEMENTS

This work was supported in part by the Kellogg Foundation, the National Institute of Child Health and Human Development (Contracts NO1-DH-2-2737 and PH43-65-640), and the Pan American Health Organization. The participation of R. E. Stickney was made possible by a Faculty Fellowship from the National Science Foundation (SEED Program).

ANNEX

MATHEMATICAL DEVELOPMENT OF THE MALNUTRITION MODEL

The properties of the model will be described by proceeding step by step through part of Fig. 8. R_{lbw} represents the risk of children being born with low weights (≤ 2.5 kg), while R_{abw} is the probability of them having acceptable birth weights (> 2.5 kg). Since the sum of these two probabilities is 1, they are not independent and we may therefore express one in terms of the other; e.g.,

$$R_{abw} = 1 - R_{lbw} \quad (1)$$

The risk of LBW (low birth weight) children being malnourished at 3 months of age is denoted by R_{ml}^* , where the subscript ml signifies malnutrition during the first age interval, and the superscript * is added to distinguish the risks of the LBW class from those of the ABW class, since these may differ substantially. The remainder of the LBW children will have acceptable nutritional status at 3 months, and this is represented by the probability

$$R_{rl}^* = 1 - R_{ml}^* \quad (2)$$

The fraction of births that result in LBW children who are then malnourished at 3 months is simply equal to the product of the risks for each of these steps:

$$M_1^* = R_{lbw} R_{ml}^* \quad (3)$$

This fraction corresponds to the prevalence at 3 months of age of malnourished LBW children based on the total number of births (LBW + ABW).

By similar reasoning, the prevalence at 3 months of acceptably nourished LBW children is

$$A_1^* = R_{lbw} R_{r1}^* \quad (4)$$

With the help of Eqs. (2) and (3), this may be rewritten in the form

$$A_1^* = R_{lbw} - M_1^* \quad (5)$$

which may also be derived from the fact that the sum of A_1^* and M_1^* must equal R_{lbw} , corresponding to the fractions of births that are in the LBW class.

Some of the LBW children who are malnourished at 3 months will recover and attain acceptable nutritional status at 6 months, with the probability being denoted by R_{r2}^* ; the others will be malnourished at 6 months also, with the risk being

$$R_{m2}^* = 1 - R_{r2}^* \quad (6)$$

Therefore, the prevalence of malnourished LBW children at 6 months is

$$M_2^* = M_1^* R_{m2}^* + A_1^* R_{c2}^* \quad (7)$$

where $A_1^* R_{c2}^*$ represents the contribution to M_2^* of children who were acceptably nourished at 3 months but become malnourished by 6 months of age, with R_{c2}^* denoting the risk corresponding to this step. By substituting Eqs. (5) and (6) into Eq. (7) we obtain

$$M_2^* = M_1^* (1 - R_{r2}^*) + (R_{lbw} - M_1^*) R_{c2}^* \quad (8)$$

which is a more convenient form because we prefer to express all equations in terms of the three input variables we selected in the text, or in terms of quantities, such as M_1^* , which represent a combination of the independent variables (e.g., see Eq. (3)). The same form of equation is obtained for M_1^* at all other age levels, so it is convenient to rewrite Eq. (7) in a generalized notation,

$$M_i^* = M_{i-1}^* (1 - R_{ri}^*) + (R_{lbw} - M_{i-1}^*) R_{ci}^* \quad (9)$$

where i may be any of the age levels, and $i-1$ denotes the preceding level. The generalized expression for A^*_i is simply

$$A^*_i = R_{lbw} - M^*_i \quad (10)$$

A similar set of equations may be derived for the class of children with acceptable birth weights, the only difference being that R_{lbw} is replaced by R_{abw} . The result is that we have a sufficient set of equations to calculate the dependent variables (prevalence of malnutrition at various ages, and the prevalence of low birth weight children) if the values of the independent variables (R_{lbw} , R_{cl} , and R_{ri}) are known.

The procedure for using longitudinal data to estimate the values of R_{lbw} and R_{cl} was described in the text. A different procedure was used to calculate the recovery probabilities, R_{ri} , because the number of children recovering is so small in some age intervals that the results are not statistically significant. This procedure utilizes Eq. (9), which may be rewritten in the following form by solving for R^*_{ri} :

$$R_{ri} = 1 - \frac{1}{M^*_{i-1}} [M^*_i - R_{cl} (R_{lbw} - M^*_{i-1})] \quad (11)$$

(Note: this equation applies also for R_{ri} , the probability for ABW children, if R_{lbw} is replaced by R_{abw} and the asterisks (*) are omitted). R_{lbw} and R^*_{cl} are evaluated by the procedure described before, and we obtain M^*_i and M^*_{i-1} from a cross-sectional analysis of the longitudinal data to determine the prevalence of malnutrition at each of the age levels in the model. The principal advantage of this approach is that it insures that the values of the dependent variables (prevalences of malnutrition) of the model will be equal to the cross-sectional results of the longitudinal study when the values of the independent variables (R_{lbw} , R^*_{cl} , R^*_{ri} , R_{cl} , and R_{ri}) are set equal to those calculated by the foregoing procedures.

After evaluating the independent variables by these procedures, the values of the other variables (e.g., R_{mi} and R_{ai}) in the model may be calculated by means of the equations derived before. The resulting values based on the longitudinal data for Santa María Cauqué are shown in Fig. 3. The arrows for the recovery step have been omitted in several age intervals because the values of R_{ri} were zero.

In the case of interventions that do not influence birth weight nor use it as an indicator of high-risk children, it is unnecessary

to have a model consisting of separate sub-models of the LBW and ABW classes. In such cases it is far more convenient to use a single model (e.g., Fig. 4) that combines both the LBW and ABW children.

In the text we illustrate how the independent variables may be estimated for two types of rural Guatemalan communities from available data.

RESUMEN

ANALISIS DE SISTEMAS EN LA PLANIFICACION DE SALUD Y NUTRICION: UN MODELO APROXIMADO QUE RELACIONA PESO AL NACER Y EDAD, CON RIESGO DE CRECIMIENTO DEFICIENTE

El presente trabajo resume la fase inicial de un esfuerzo por desarrollar métodos semicuantitativos para el planeamiento de programas de nutrición y de salud. Su enfoque general es utilizar, cuando se considere conveniente, métodos de análisis de sistemas y de investigación de operaciones. Principalmente, sin embargo, se hace énfasis en el desarrollo de un análisis aproximado simplificado, que los sectores gubernamentales de planificación podrían aplicar fácilmente en la evaluación de varios programas potenciales para lograr objetivos específicos en nutrición y salud, satisfaciendo a la vez ciertas restricciones (por ejemplo, presupuesto, facilidades, personal).

Un elemento esencial del análisis es un modelo que aporte una descripción aproximada de la desnutrición (crecimiento inadecuado, como el que indica el peso para la edad) y mortalidad en términos de las variables susceptibles de ser afectadas por programas de intervención. Inicialmente los esfuerzos en este campo se han concentrado en utilizar los resultados de dos estudios longitudinales del INCAP para desarrollar modelos que relacionen la incidencia de la desnutrición (segundo y tercer grados según la escala de Gómez) a la edad y al crecimiento previo, incluyendo peso al nacer. Los dos estudios cubren comunidades guatemaltecas que varían considerablemente en cuanto a condiciones étnicas, socioeconómicas y ecológicas. Puesto que son tentativos, los modelos propuestos se comentan sólo cualitativa y no cuantitativamente.

Los modelos pueden servir como base para estimar las consecuencias de programas potenciales dirigidos hacia diferentes grupos, tales como mujeres embarazadas y niños cuyo peso al nacer o después del nacimiento caen por debajo de los niveles prescritos. Se comentan los posibles beneficios que pueden derivarse del uso de modelos de este tipo en la planificación de salud y nutrición.

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PULPA Y PERGAMINO DE CAFE. XII. EFECTO DEL ALMACENAMIENTO SOBRE EL VALOR NUTRITIVO DE LA PULPA DE CAFE PARA TERNEROS ¹

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RESUMEN

Se estudió en terneros en rápido crecimiento, la composición química y el valor nutritivo de la pulpa de café deshidratada al sol y almacenada por 7, 13 y 17 meses, y de pulpa ensilada durante 4, 10 y 14 meses, que luego se deshidrató al sol.

No se produjeron cambios en la composición química durante el almacenamiento de la pulpa de café deshidratada, pero en la pulpa ensilada sí se observó un descenso en el contenido de fibra cruda y un alza del extracto libre de nitrógeno.

Se realizaron tres experimentos de crecimiento empleando tres grupos de terneros raza Holstein de 3 a 5 meses de edad, con un peso promedio de 95 kg en el primer y segundo ensayo, y de 130 kg en el tercero. En el primer ensayo se usaron 18 animales, y 24 en los dos restantes. En cada caso los animales se dividieron en tres grupos asignados al azar a cada uno de los

1. Este trabajo se llevó a cabo con fondos otorgados por el International Development Research Centre, Ottawa, Canadá (Subvención N^o INCAP 840) y por la Organización de Estados Americanos (OEA), con sede en Washington, D. C.
2. Científicos de la División de Ciencias Agrícolas y de Alimentos del Instituto de Nutrición de Centro América y Panamá.
3. Perito Agrónomo a cuyo cargo se encuentra la administración de la Finca Experimental del INCAP.
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Publicación INCAP E-860.

Recibido: 18-8-1975.

siguientes tres tratamientos: el control, que contenía 48% de cascarilla de algodón, y dos tratamientos consistentes en raciones con 30% de pulpa de café deshidratada ó 30% de pulpa ensilada, incluida en substitución d la cascarilla de algodón. Básicamente, la diferencia entre los tres experimentos consistió en el tiempo de almacenamiento o ensilaje de la pulpa. En todos los casos el aumento ponderal inducido por las raciones con pulpa de café (1.00, 0.90, y 0.98 kg/día y 1.06, 0.94 y 1.08 kg/día, respectivamente) fueron significativamente menores ($P < 0.05$) que aquéllos resultantes de administrar la ración control (1.21, 1.08 y 1.19 kg/día). Asimismo, se observó una merma en el consumo de las raciones que contenían pulpa de café, pero la eficiencia de conversión alimenticia fue similar en todos los tratamientos. El rendimiento de los terneros que consumieron pulpa ensilada fue superior al de los alimentados con pulpa deshidratada, especialmente en el tercer experimento en el que las ganancias de peso de los primeros ocurrieron con rapidez significativamente mayor ($P < 0.05$).

Se concluye que el tiempo de almacenamiento no modifica el valor nutritivo de la pulpa de café para ganado bovino y que el ensilaje es un proceso adecuado para almacenar este material y posiblemente también para mejorar su valor nutritivo.

INTRODUCCION

Hoy día existe mucho interés en utilizar la pulpa de café como alimento para animales con el propósito de reducir los costos de producción de carne para consumo humano, y evitar, a la vez, la contaminación ambiental que este subproducto agrícola ocasiona¹. Sin embargo, uno de los problemas que presenta la utilización de la pulpa de café en ese sentido es su alto contenido de agua, lo que dificulta su manejo, transporte y almacenamiento, elevando su costo.

El trabajo que aquí se presenta persigue la búsqueda de posibilidades de procesar la pulpa de café por deshidratación o ensilaje, con el objeto de lograr una mayor eficiencia no sólo en cuanto a su manejo y transporte, sino también en lo que respecta a la utilización de este desperdicio agrícola en el campo de la nutrición animal. Con este objetivo en mente se estudiaron los efectos de diferentes períodos de almacenamiento sobre la composición química y el valor nutritivo de la pulpa de café, deshidratada o ensilada previamente, para terneros rumiantes en rápido crecimiento dentro de un sistema intensivo de producción de carne.

MATERIALES Y METODOS

Los experimentos se realizaron en la Finca Experimental del INCAP, situada en el altiplano de Guatemala a 1,480 metros

(5,151 pies) sobre el nivel del mar. La pulpa de café se obtuvo en dos partes al momento de ser procesada en un beneficio comercial ubicado en la misma región. La primera parte se adquirió en el mes de octubre de 1971 y fue de inmediato deshidratada al sol por tres días y almacenada en bolsas de papel durante un período de 7, 13 ó 17 meses. La otra parte, que se obtuvo en el mes de enero de 1972, fue parcialmente deshidratada al sol para reducir su contenido de humedad a cerca de 65% antes de ser ensilada en un silo de trinchera con el agregado de 5% de melaza. Se almacenó en esta forma por períodos de 4, 10 y 14 meses, y luego fue deshidratada al sol.

La pulpa seca procesada por ambos métodos se molió en un molino de martillos a un grueso de 20 mallas antes de utilizarse para la elaboración de las raciones N° 2 y N° 3, cuya composición se muestra en el Cuadro 1. La ración N° 1 sirvió como control en tres experimentos de crecimiento efectuados con terneros rumiantes raza Holstein de 3 a 5 meses de edad y cuyo peso promedio fue de 95 kg en los primeros dos ensayos, y de 130 kg en el tercero. Estos animales fueron criados artificialmente mediante un sistema de destete precoz en la misma Finca Experimental y, antes del estudio su alimentación consistió de un concentrado iniciador y forraje seco. La diferencia entre los ensayos radicó básicamente en el tiempo de almacenamiento de la pulpa de café, deshidratada o ensilada. En el primer caso se utilizó pulpa deshidratada y almacenada durante 7 meses, y

CUADRO 1

COMPOSICION PORCENTUAL DE LAS RACIONES EMPLEADAS EN LOS ENSAYOS DE CRECIMIENTO

Ingredientes	Tratamientos		
	1	2	3
Harina de algodón	15.0	15.0	15.0
Afrecho de trigo	15.0	15.0	15.0
Melaza de caña	20.0	20.0	20.0
Minerales *	1.0	1.0	1.0
Urea	1.0	1.0	1.0
Cascarilla de algodón	48.0	18.0	18.0
Pulpa de café deshidratada **	—	30.0	—
Pulpa de café ensilada y deshidratada ***	—	—	30.0

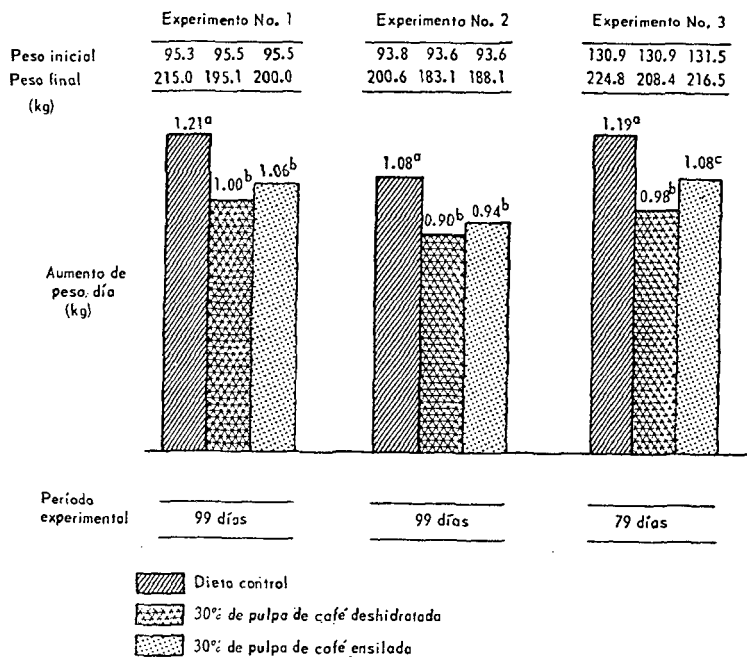
* Composición de la mezcla de minerales: hueso molido, 28.6%; carbonato de calcio, 23.8%; cloruro de sodio, 28.0%; azufre, 13.0%; y minerales menores, 1.8%.

** Ensayo 1: almacenada por 7 meses; ensayo 2: almacenada por 13 meses; ensayo 3: almacenada por 17 meses.

*** Ensayo 1: ensilada por 4 meses; ensayo 2: ensilada por 10 meses; ensayo 3: ensilada por 14 meses.

CUADRO 3
COMPOSICION QUIMICA DE LAS RACIONES

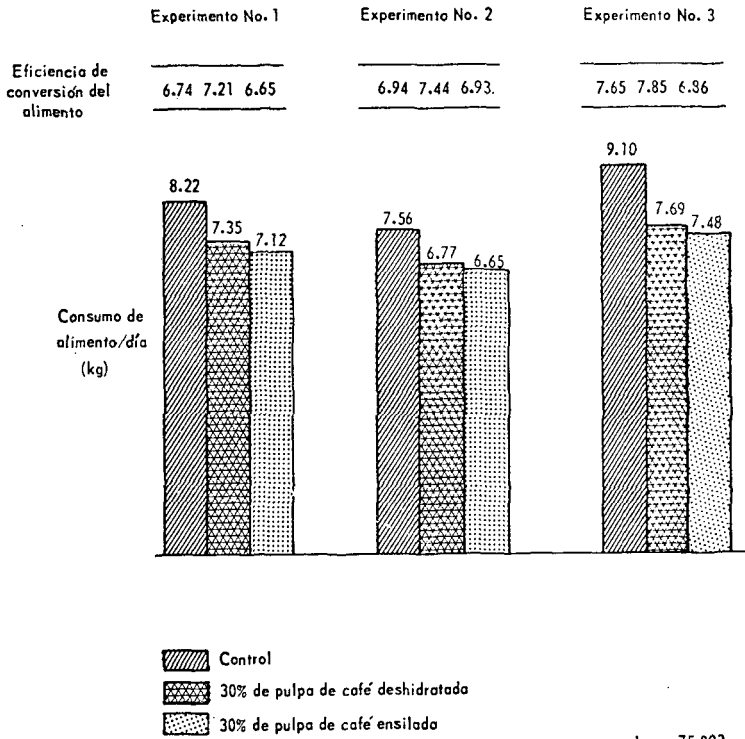
	Raciones								
	Experimento N° 1			Experimento N° 2			Experimento N° 3		
	1	2	3	1	2	3	1	2	3
Materia seca, %	95.5	94.5	95.6	94.6	94.3	94.7	94.6	94.4	94.6
Composición de la materia seca, %:									
Proteína cruda	13.4	15.3	15.1	16.3	18.0	17.6	13.1	16.3	16.2
Extracto etéreo	2.5	2.5	2.5	2.6	2.8	3.0	2.9	3.1	2.9
Fibra cruda	30.0	21.1	21.1	30.8	21.1	21.4	28.2	22.1	20.9
Cenizas	5.6	7.0	7.0	5.0	7.0	7.1	5.6	6.9	7.5
Extracto libre de nitrógeno	48.5	54.1	54.3	45.3	51.1	50.9	50.2	51.6	52.5



a, b, y c Las letras indican diferencias estadísticamente significativas.

¹ncap 75-894

Figura 1



Incap 75-893

Figura 2

Al final de cada tratamiento y en lo que respecta a los parámetros bioquímicos, se obtuvieron los resultados que se exponen en el Cuadro 4. Como los datos lo revelan, las cifras para nitrógeno de urea, proteína y albúmina fueron prácticamente constantes en todos los tratamientos; no sucedió así en el caso de la glucosa y los ácidos grasos libres, ya que hubo una mayor variación en los resultados, pero sin traducirse en ninguna tendencia significativa.

DISCUSION

Los resultados referentes a la composición química de la pulpa de café que se obtuvieron en este estudio son muy similares a los de Bressani *et al.*¹⁴, y Bressani, Estrada y Jarquín¹⁵ excepto en el contenido de fibra cruda, que fue un poco más alto en este caso. Asimismo, los valores de cafeína y taninos son comparables a los encontrados por Jaffé y Ortiz¹⁶. Los únicos cambios notables que se produjeron durante el período de ensilaje fueron la disminución de fibra cruda y el aumento de extracto libre de nitrógeno, lo cual coincide con los datos notificados por Choussy¹⁷.

El contenido de cafeína prácticamente no sufrió cambios durante los últimos diez meses de ensilaje y almacenamiento. Desafortunadamente no se analizó la pulpa fresca antes de ser sometida a los diferentes procesos. Por este motivo no se pudo establecer si hubo o no variación en el contenido de cafeína durante los primeros siete meses de tratamiento.

En los tres experimentos se encontró que la pulpa de café, ya fuese ensilada o almacenada, produjo una menor eficiencia alimenticia en los animales, hallazgo que coincide con los resultados obtenidos por Jarquín y colaboradores¹³ y por Braham *et al.*¹⁸ con dietas usando fórmulas similares.

Bressani y colaboradores¹⁴ en sus estudios con ratas, encontraron que el almacenamiento produjo un descenso en el contenido de cafeína de la pulpa, de 0.90 a 0.45%, lo cual indujo a su vez una disminución del efecto adverso de la pulpa sobre el crecimiento de los animales. Sin embargo, en el presente caso, los valores de cafeína fueron más bajos y se mantuvieron constantes durante todo el período en que se realizaron los ensayos de crecimiento.

La falta de efectos significativos de la pulpa de café sobre la concentración de metabolitos en el suero sanguíneo no coincide con los resultados de Braham y colaboradores¹⁸, que indican un

CUADRO 4

VALORES SERICOS DE TERNEROS ALIMENTADOS CON PULPA
DE CAFE DESHIDRATADA Y ENSILADA

Tratamiento	N de urea mg/100 ml		Proteína g/100 ml		Albúmina g/100 ml		Glucosa mg/100 ml		Acidos grasos libres mcg/lt	
	\bar{X}	E.E.	\bar{X}	E.E.	\bar{X}	E.E.	\bar{X}	E.E.	\bar{X}	E.E.
Dieta control	9.5	0.6	6.7	0.1	3.0	0.1	82	5.5	334	49.7
30% de PCD y almacenada por 7 meses	18.3	2.3	6.7	0.2	3.0	0.1	73	0.7	284	10.6
30% de PCD y almacenada por 11 meses	12.0	0.8	6.4	0.1	3.1	0.1	90	4.4	315	61.4
30% de PCD y almacenada por 17 meses	10.0	0.7	6.4	0.1	3.1	0.1	68	1.4	430	27.2
30% de PCE por 4 meses	10.8	1.9	6.5	0.3	3.0	0.2	81	5.5	316	69.3
30% de PCE por 10 meses	10.0	0.7	6.4	0.2	3.0	0.1	93	4.0	259	22.0
30% de PCE por 14 meses	11.0	0.4	6.2	0.1	3.0	0.1	65	3.2	473	16.6

PCD = Pulpa de café deshidratada.

PCE = Pulpa de café ensilada.

E.E. = Error estándar.

aumento de ácidos grasos libres en terneros que recibieron 30 a 48% de pulpa en la dieta. En el presente estudio, la concentración de estos metabolitos permaneció dentro de los límites considerados como normales para animales rumiantes¹⁹; no obstante, las variaciones de los resultados con respecto al promedio fueron amplios como lo muestra el error estándar en el Cuadro 4. Esto puede ser atribuido al "stress" a que fueron sometidos los animales en el momento de la punción, lo cual puede inducir la descomposición de la grasa del tejido adiposo y aumentar la concentración de ácidos grasos libres en la sangre²⁰. En base a estos hallazgos, se recomienda un control más severo durante la obtención de las muestras de sangre a fin de evitar al máximo todos aquellos factores susceptibles de alterar los resultados.

SUMMARY

COFFEE PULP AND COFFEE HULLS. XII. EFFECT OF STORAGE OF COFFEE PULP ON ITS NUTRITIVE VALUE FOR CALVES

Coffee pulp, dehydrated and stored for 7, 13 and 17 months or ensiled for 4, 10 and 14 months, was studied in calves with a rapid growing rate. Storage of dehydrated coffee pulp did not affect its chemical composition, but ensiling reduced crude fiber and increased its nitrogen free extract content after 10 and 14 months.

Three growth trials were carried out with Holstein calves averaging 95 kg in the first and second trials, and 130 kg in the third. Eighteen calves were used in the first trial and 24 in each of the other two. In each trial the animals were divided into three equal groups and randomly assigned to one of the following treatments: control, which contained 48% cottonseed hulls, and the other two, with 30% dehydrated coffee pulp or 30% ensiled coffee pulp. Basically, the difference between trials consisted in the time of storage or ensiling of coffee pulp.

In all trials, weight gains of calves fed coffee pulp (1.00, 0.90 and 0.98 kg/day, and 1.06, 0.94 and 1.08 kg/day, respectively) were significantly lower ($P < 0.05$) than the weight gains induced by the control ration (1.21, 1.08 and 1.19 kg/day). Feed intake was also lower, but feed conversion ratio was higher for those rations containing coffee pulp. Calf performance was better with ensiled than with dehydrated coffee pulp, particularly in the third trial, where the differences in weight gains were significantly higher ($P < 0.05$).

It is concluded that storage time does not change nutritive value of coffee pulp; and that ensiling is an adequate process for storing pulp during coffee harvesting, and, possibly also, for improving its nutritive value.

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ARGENTINA

Determinación de Ag, Cu, Pb, Sn, Fe, Ca, Zn, Mg, K, y Mn por espectrofotometría de absorción atómica en conservas de tomates.—C. Acatini, S. N. Berman, O. de Colombo, O. Fondo. (Laboratorio de Investigaciones y Contraverificaciones, Dirección General de Saneamiento. Municipalidad de la Ciudad de Buenos Aires). *Rev. de la Asociación Bioquímica Argentina*. 40, 175-183, 1975.

Vistos los límites establecidos en el Código Alimentario Argentino para algunos elementos (Ag, Cu, Pb, Sn, Sb, Zn) y la sensibilidad hallada en determinaciones por espectrofotometría de absorción atómica, de esos y otros elementos que consideramos de valor en los análisis de alimentos, se los agrupó de la siguiente manera:

- 1º grupo: Ag, Cu, Pb, Sn, Sb, Fe, Mn.
- 2º grupo: K.
- 3º grupo: Ca, Zn.
- 4º grupo: Mg.

Se trabajó sobre conserva de tomate. La muestra se licúa y homogeneiza, se le agrega HCl, se centrifuga y se filtra; en ella se determinan los elementos del primer grupo. Para los del segundo se la diluye al décimo. Para determinar los del tercer grupo se pesa 1 g de tomate, se le agrega soluciones de EDTA y Sr, se lleva a 100 ml con agua destilada y se filtra. Para los del cuarto grupo se usa esta solución diluida al décimo y con agregado de EDTA y Sr.

Para minimizar las interferencias físicas y químicas se trabaja utilizando como matriz tomate en condiciones semejantes al envasado al que se le agregan los standards y se traza la curva de calibración de cada elemento.

Se mencionan las condiciones más favorables para la determinación de cada uno de los elementos, la sensibilidad hallada y la precisión del método.

The effect of fat deprivation on the allosteric inhibition by fluoride of the (Mg^{2+}) -ATPase and $(Na^+ + K^+)$ -ATPase from rat erythrocytes.—Ricardo N. Farías, Adriana L. Goldemberg and Raúl E. Trucco. (Departamento de Química Biológica, Instituto de Ciencias Químicas, Ciudad Universitaria, Córdoba, Argentina). *Archives of Biochemistry and Biophysics*, 139, 38-44. 1970.

It has been found that the ATPases (ATP phosphohydrolase, EC 3.6.1.3) from rat erythrocytes are inhibited by P^- .

Allistic type of kinetics with $n = 2.1$ for the (Mg^{2+}) -ATPase and 2.8 for the $(Na^+ + K^+)$ -ATPase have been obtained for the inhibition by P^- .

In animals fed fat-deficient diet the value of n for the (Mg^{2+}) -ATPase changed from 2.1 to 1.4 and for the $(Na^+ + K^+)$ -ATPase from 2.7 to 1.5. When these animals were then fed fat-sufficient diet the value of n increased to the normal values.

The possibility that changes in the unsaturated fatty acid composition of the erythrocyte membrane were responsible for the changes in the value of n is discussed.

Allosteric changes of p-nitrophenylphosphatase from rat erythrocytes in fat deficiency.—Adriana L. Goldemberg, Ricardo N. Farías and Raúl E. Trucco. (Departamento de Química Biológica, Facultad de Ciencias Químicas, Universidad Nacional de Córdoba, Ciudad Universitaria, Córdoba, Argentina). *The Journal of Biological Chemistry*, 247, 4299-40304. 1972.

The kinetic properties of the p-nitrophenylphosphatase of red cell ghosts from rats fed fat-sufficient and fat-deficient diets were investigated. With this system the enzyme shows hyperbolic saturation curves. In the fat-sufficient case, positive cooperativity with $n < 1.5$ for F^- were observed.

Evidence for a different allosteric transition in the p-nitrophenylphosphatase from fat-deficient rats is supported by the following facts: (a) values of $n > 1.5$ in F^- inhibition and (b) nonsigmoidal kinetics for K^+ activation with $n < 1.5$.

In the activation by H^+ , the heterotropic effect of F^- and of the substrate alters the values of n and $K_{0.5}$ in fat-deficient rats but in fact-sufficient rats the corresponding effects is only on the $K_{0.5}$ values.

Arrhenius plots for the p-nitrophenylphosphatase between 7 and 45° showed for the enzyme from fat-sufficient rats an inflection point at 30°; for the p-nitrophenylphosphatase for deficient animals two inflection points were observed, one at 30° and another at 37°.

Evidence is presented showing that in fat-deficient rats the p-nitrophenylphosphatase of the red cell ghost has an allosteric transition different from the corresponding controls.

The allosteric transitions from membrane-bound enzymes: Behavior of erythrocyte acetylcholinesterase from fat-deficient rats.—Roberto D. Morero, Bernabé Bloj, Ricardo N. Fariás and Raúl E. Trucco. (Instituto de Química Biológica, Facultad de Bioquímica, Química y Farmacia, Universidad Nacional de Tucumán, Chacabuco 461, San Miguel de Tucumán, Tucumán, Argentina). *Biochimica et Biophysica Acta*, 282, 157-165. 1972.

The allosteric behavior of acetylcholinesterase (acetylcholine hydrolase, E.C. 3.1.1.7) from red cell ghosts of rats fed fat-sufficient and fat-deficient diets was investigated. Allosteric type kinetics with $n = 1.6$ have been obtained for the inhibition by F^- in rats fed a fat-sufficient diet. In animals fed a fat-deficient diet the values of n changed from 1.6 to 1.0. When these animals were then fed a fat-sufficient diet the values of n shifted from 1.0 to 1.6. This in vivo reversion was obtained after 8 days of refeeding.

Two types of changes in the values of n were obtained in vitro in fat-deficient rats: (1) from 1.0 to 1.6 by solubilization of the membrane-bound enzyme with Triton X-100, (2) from 1.6 to 1.0 by reconstitution of the membrane-like structure from the soluble enzymatic preparation. The possibility that the structure of the membrane could be responsible for the changes in the phenomenon of phenotypic allosteric desensitization in the membrane-bound enzymes is discussed.

Allosteric transitions and membrane-bound ATPase from rat tissues: The effect of rat deprivation on the allosteric inhibition by fluoride.—Adriana L. Goldemberg, Ricardo N. Fariás and Raúl E. Trucco. (Departamento de Química Biológica, Laboratorio de Microbiología, Facultad de Ciencias Químicas, Universidad Nacional de Córdoba, Córdoba, Argentina). *Biochimica et Biophysica Acta*, 191, 489-493. 1973.

In rats fed a fat-sufficient diet, ATPases (ATP phosphohydrolase, EC 3.6.1.3) from heart, kidney and brain microsomes showed allosteric kinetics for the inhibition by F^- , with values of $n = 2.0$. In rats fed a fat-free diet, the values of n for the ATPases changed from 2.0 to 1.0 in heart and kidney microsomes. When these animals were then fed a fat-sufficient diet the values of n reached the control values. In brain microsomal ATPases no modification of the values of n were found between both groups of animals. The regulatory properties of the membrane on bound ATPases are discussed.

Membrane lipid fatty acids and regulation of membrane-bound enzymes. Allosteric behaviour of erythrocyte Mg^{2+} -ATPase ($Na^+ + K^+$)-ATPase and acetylcholinesterase from rats fed different fat-supplemented diets.—Bernabé Bloj, Roberto D. Morero, Ricardo N. Fariás and Raúl E. Trucco. (Instituto de Química Biológica, Facultad de Bioquímica, Química y Farmacia, Universidad Nacional de Tucumán, Chacabuco 461, San Miguel de Tucumán, Tucumán, Argentina, and Laboratorio de Microbiología Industrial, De-

partamento de Tecnología Farmacéutica, Facultad de Farmacia y Bioquímica, Universidad Nacional de Buenos Aires, Junín 956, Buenos Aires, Argentina). *Biochimica et Biophysica Acta*, 311, 67-79. 1973.

Studies were carried out to determine the Hill coefficients for the inhibition by F^- of the erythrocyte membrane-bound Mg^{2+} -ATPase, $(Na^+ + K^+)$ -ATPase and acetylcholinesterase from rats fed with seven different diets. Five groups were fed with different natural fats or oil supplements, one with a hydrogenated fat supplement and the other with fat-free diet. The responses of the red cell fatty acids to dietary fats were recorded. The values of n for the inhibition by F^- of the three enzymes revealed a particular and different behaviour in each group. Correlation between the fatty acid compositions of erythrocyte membranes and cooperativity of each enzyme were calculated. The results indicate that neither the essential fatty acid family nor the non-essential ones are particularly involved in the allosteric phenomena. The increase of the double bond index/saturation ratio of fatty acids, which is taken as indicative of membrane fluidity, was accompanied in an inverse manner by changes in allosteric transitions of the $(N^+ + K^+)$ -ATPase and acetylcholinesterase, whereas the Mg^{2+} -ATPase was not dependent on this ratio. Diminution of membrane fluidity, carried out by *in vitro* increase of its cholesterol content, yields confirmatory results of this regulatory mechanism since the value of n for acetylcholinesterase shifted as predicted.

These facts indicate that the membrane fluidity is a physiological regulator for the allosteric behaviour of the membrane-bound enzymes and that each enzyme exhibits a particular behavior in this phenomenon.

Effect of essential fatty acid deficiency on the arrhenius plot of acetylcholinesterase from rat erythrocytes.—Bernabé Bloj, Roberto D. Morero and Ricardo N. Fariás. (Instituto de Química Biológica, Facultad de Bioquímica, Química y Farmacia, Universidad Nacional de Tucumán, Chacabuco 461, San Miguel de

Tucumán, Argentina). *Journal of Nutrition*, 104, 1265-1272. 1974.

Arrhenius plot of erythrocyte acetylcholinesterase was studied at different pH values in four groups of rats. Two groups were fed EFA-sufficient diets with lard or corn oil as the dietary fat. The other two groups were fed EFA-deficient diets: a basic, fat-free diet, and the same supplemented with hydrogenated beef fat. The Arrhenius plot of membrane-bound acetylcholinesterase from EFA-sufficient animals was found to have a breakpoint about 20° at pH 8.0 with lower activation energy at higher temperatures. The enzyme from EFA-deficient animals exhibited a breakpoint about 28°, the activation energies being lower than that of the enzyme from EFA-sufficient animals above and below this point. Solubilization of the membrane with Triton X-100 led to a shift in the breakpoint and to an increase in the activation energies in the enzyme from EFA-deficient animals. No changes were detected with preparations from EFA-sufficient animals after the treatment. After reconstitution of membrane-like material from the soluble EFA-deficient preparation, the distinctive enzymatic behavior was restored. The results indicate that the Arrhenius plot of the acetylcholinesterase is changes when the enzyme is bound to an EFA-deficient membrane.

Regulation of allosteric membrane-bound enzymes through changes in membrane lipid composition.—Ricardo N. Fariás, Bernabé Bloj, Roberto D. Morero, Faustino Siñeriz and Raúl E. Trucco. (Instituto de Química Biológica, Facultad de Bioquímica, Química y Farmacia, Universidad Nacional de Tucumán, Chacabuco 461, San Miguel de Tucumán and Laboratorio de Microbiología Industrial, Departamento de Tecnología Farmacéutica, Facultad de Farmacia y Bioquímica, Universidad Nacional de Buenos Aires, Junín 956, Buenos Aires, Argentina). *Biochimica et Biophysica Acta*, 415, 231-251. 1975.

I. Introduction.

- ii. Effect of fat-free diet on cooperativity of membrane-bound enzymes.

- III. Relationship between membrane lipid fluidity and enzyme cooperativity.
 - A. Mammalian membranes.
 1. Changes in fatty acid composition.
 2. Changes in cholesterol content.
- IV. Some properties of the cooperative enzymes that showed correlation with the membrane lipid fluidity.
 - A. Localization.
 - B. Dependence on the lipids for enzymatic activity.
- V. Influence of membrane integrity for lipid effect on the enzyme cooperativity "Macroeffector".
- VI. The application of Hill coefficient measurement as a probe for membrane structure.
 - A. Arrhenius plots and Hill plots of the membrane-bound enzymes.
 - B. Change of membrane fluidity and Hill coefficient in response to hormone action.
- VII. Speculations on the membrane allosteric control.
 - A. Possible general nature of membrane allosteric control phenomena.
 - B. Specific functions of the enzymes studied.
 1. Acetylcholinesterase.
 2. ATPases associated to vectorial ion-transport systems.
 3. ATPases associated to vectorial electron-transport systems.

La desnutrición: un estudio clínico evolutivo acerca de su prevención y tratamiento en el lactante menor.—Raúl Platero Bastos. (III Cátedra de Pediatría de la Universidad de Buenos Aires). *La Semana Médica*, 148 (4940), 335-340. 1976.

Se ha realizado un estudio clínico longitudinal con seguimiento por tres meses de 50 lactantes menores desnutridos de todos los grados. Se trató de determinar la cantidad de calorías y proteínas óptimas que se deben indicar en una dieta simple y aceptada por los lactantes desnutridos separados en grupos según el grado y la edad y los incrementos antropométricos correspondientes así como determinar el status laboral, habitacional y sanitario de sus familias. Se realizó la comparación estadística entre los aumentos de peso mensuales según el grado de desnutrición previo y según

los tramos de edades estudiadas llegándose a la conclusión en esta serie de que las diferencias no son significativas. Cuanto menor fue la edad del comienzo mejores resultados se obtuvieron y que el tratamiento debe ser proporcionalmente más largo de acuerdo a la edad de capacitación. La ración calórica aceptada por el lactante y la cuota proteica no tuvo en esta casuística las diferencias generalmente mencionadas resultando prácticamente iguales en los tres grupos de edad y en los tres grados de desnutrición. En cuanto a la situación social, laboral y condiciones sanitarias y habitacionales se comprueban en casi todos los casos graves carencias en los tres ítems, reafirmando en la opinión del autor que la desnutrición del lactante es una enfermedad de la pobreza.

COLOMBIA

Consideraciones sobre alimentos de alto valor nutricional y bajo costo.—Norton Young L. y Teresa Salazar de Buckle. *Rev. Inst. Inv. Tecn. Bogotá*, N° 91, 7-17, 1974. 9 Ref.

Contribución al estudio de los métodos analíticos para la determinación de fibra cruda en alimentos concentrados para animales.—Rafael Guzmán. *Rev. Inst. Inv. Tecn. Bogotá*, N° 91, 18-31, 1974. 7 Ref.

Comparación de dos métodos para la determinación de residuos de insecticidas en alimentos.—María Inés M. de Cuevas. *Rev. Inst. Inv. Tecn. Bogotá*, N° 95, 37-40, 1975. 14 Ref.

Aislado de proteínas a partir de tortas de algodón colombianas.—Teresa Salazar de Buckle y Gloria Silva S. *Rev. Inst. Tecn. Bogotá*, N° 95, 17-31, 1975. 14 Ref.

Situación actual del mercado internacional de la carne. La posición de Colombia.—Felipe Carrizosa Restrepo. *Rev. Inst. Inv. Tecn. Bogotá*, N° 95, 33-36. 1975.

Molienda fina y clasificación neumática de harina de pulimento de Arroz.—Marco F. Bocanegra y

Jairo A. González S. *Rev. Inst. Inv. Tecn. Bogotá*, Nº 96, 31-53. 8 Ref.

Contribución de la tecnología al cumplimiento de patrones nutricionales en países en desarrollo.—Teresa Salazar de Buckle. *Rev. Inst. Inv. Tecn. Bogotá*, Nº 97, 22-45, 1975. 31 Ref.

Factores económicos y sociales relacionados con la sustitución de trigo en pan y pastas.—Jorge A. Beltrán B. *Rev. Inst. Inv. Tecn. Bogotá*, Nº 97, 8-21. 1975.

El papel de la agroindustria en el mejor aprovechamiento de los recursos alimentarios regionales y el desarrollo económico.—Germán Valenzuela S. *Rev. Inst. Inv. Tecn. Bogotá*, Nº 97, 66-52. 1975.

Enteropathy in adult protein malnutrition: ultrastructural findings.—Edgar Duque, Hernán Lotero, Oscar Bolaños, and Luis G. Mayoral. (Dept. de Medicina y Patología, Universidad del Valle, Cali, Colombia). *Am. J. Clin. Nutr.* 28: 914-924. 1975.

As part of a comprehensive study in adult patients with severe primary protein malnutrition, jejunal ultrastructural studies have been performed in nine adults in the malnourished state. Malnutrition was severe in all. D-Xylose malabsorption and abnormal fecal fat excretion were present in most. The main ultrastructural abnormalities encountered were: microvillar abnormalities such as shortening, diminished numbers, abnormal positioning, branching, and mesalike fusion of the microvilli; and abnormalities in the lamina propria characterized by deposits of osmioidense material and collagen fibers below the basement membrane of the epithelial cells and of the capillaries. None of the aforementioned findings were noted in our control cases. These ultrastructural alterations of severely malnourished adults are nonspecific, since they have already been described in other enteropathies frequently encountered in the tropics.

Enteropathy in adult protein malnutrition light microscopic findings.—Edgar Duque, Oscar Bolaños, Hernán Lotero and Luis

G. Mayoral. (Dept. de Medicina y Patología, Universidad del Valle, Cali, Colombia). *Am. J. Clin. Nutr.* 28: 901-913. 1975.

Light microscopic evaluation of the intestinal abnormalities seen in 35 severely malnourished adults revealed changes which are common to other well-documented enteropathies. These included shortening, widening and fusion of the villi, lost convolution of the nuclear line, and diminished epithelial cell height. With Masson's trichrome stain, dense material was seen to have accumulated in a subepithelial location in villi (as described in other enteropathies), in crypts, and perivascularly around the capillaries of the lamina propria. Two findings however appear to characterize the severely malnourished state: a consistent significant reduction of intestinal mucosal thickness, and in many cases atrophy of the crypts. Statistical analysis of the total mucosal thickness data does not justify five but rather three histological categories. With protein repletion as the sole therapeutic modality, 17 patients in which adequate biopsy samples were available at its completion showed significant amelioration of the aforementioned histological abnormalities, as well as normalization of their previous absorptive defects. The mild enteropathy of severe protein malnutrition must be considered in the differential diagnosis of malabsorption in a tropical setting.

Enteropathy in adult protein malnutrition: a review of the Cali experience.—Luis G. Mayoral, Oscar Bolaños, Hernán Lotero and Edgar Duque. (Dept. de Medicina y Patología, Escuela de Medicina, Universidad del Valle, Cali, Colombia). *Am. J. Clin. Nutr.* 28: 894-900. 1975.

Since 1964, 41 patients with strictly defined, severe primary (dietetic) protein malnutrition have been studied under metabolic ward conditions during prolonged periods, initially on a low (20 g) and later on a high (100 g) protein diet. Clinical, nutritional, hematological, intestinal absorptive and histological studies were performed in the malnourished state, during and after protein repletion. Classical signs and symptoms of malnutrition, lasting for at least 4 months, were present in most patients. Mild diar-

rhea was frequent. All were normoblastically anemic, hypoproteinemic, and hypocholesterolemic; serum folate values were normal or low but serum B_{12} values were normal or high. Liver biopsy showed fatty liver in the cases where it was performed. Mild malabsorption was detected in over one-half of the patients, with moderate Intestinal radiological abnormalities. Malabsorption was independent of concomitant folate deficiency. All the clinical, absorptive and histological abnormalities reversed with treatment consisting only of a high protein diet. In addition to protein lack, another factor has to be invoked in the pathogenesis of the intestinal abnormalities present in severely malnourished adults from rural areas in the tropics.

CUBA

Bocio puberal. Estudio de 30 casos. —Rubén S. Padrón Durán. (Servicio Provincial de Endocrinología y Enfermedades Metabólicas Camagüey). Rev. Cub. Ped. 47: 405-410. 1975.

Se presentan los resultados obtenidos en el estudio de 30 pacientes portadores de bocio puberal. Se destacan el antecedente familiar de tiroidopatía, el predominio en el sexo femenino, la ausencia de síntomas típicos, así como los caracteres del bocio. Insistimos en la utilidad del índice de tirotoxicosis y planteamos la correlación normal entre talla, edad ósea, y edad cronológica. Se hace énfasis en la normalidad del PBI como una prueba más del eutiroidismo de estos pacientes.

Índice energía/proteína: Un nuevo aporte para la evaluación del estado de nutrición. I. Valores en niños sanos de edad preescolar. —Manuel Amador, Jorge Bacallao, Mirta Hermelo, Raúl Hernández y Cristóbal Tolón. (Departamento de Pediatría y Centro de Cibernética, Facultad de Ciencias Médicas, Universidad de La Habana, Cuba).

Se describe un nuevo índice antropométrico (Índice energía/proteína) que relaciona en forma de cociente el pliegue tricípital transformado y el logaritmo₁₀ del perímetro muscular braquial.

Este índice presenta una escasa variabilidad en niños bien nutridos entre 12 y 59 meses de edad y no está influido en general por el sexo. Los valores medios para este índice, obtenidos en 126 niños fueron de 1.650 ± 0.020 y en 121 niñas, de 1.663 ± 0.018 ($x \pm 1.96 \sigma x$). Igualmente el índice E/P fue calculado a partir de los valores que para el pliegue cutáneo tricípital y el perímetro braquial aparecen en tablas de referencia internacionalmente aceptadas. Se considera que, al relacionar cuantitativamente la adiposidad con la masa muscular, este índice permite evaluar las afectaciones relativas del metabolismo energético y del metabolismo proteínico y de esta forma sería posible discriminar entre las distintas líneas de desarrollo de la desnutrición proteico-energética, aun cuando ésta se halle en su etapa subclínica.

GUATEMALA

Head and chest circumferences in rural Guatemalan Ladino children, birth to seven years of age. —R. M. Malina, J. P. Habicht, R. Martorell, A. Lechtig, C. Yarbrough and R. E. Klein. (INCAP, Guatemala). The American Journal of Clinical Nutrition, 28: 1061-1070. 1975.

Growth patterns in head and chest circumferences are reported for a mixed-longitudinal sample of rural Guatemalan Ladino children from birth to 7 years of age. The sample is representative of a population with suboptimal nutrition. Both circumferences show similar rapid growth from birth through 9 months, after which chest circumference continues to increase more rapidly, while head circumference increases at a slower rate. Chest circumference provides nutritional information apparently not contained in length and weight. Compared to a sample of well-nourished children from Denver the head circumferences of Guatemalan children are consistently smaller. Differences are relatively small at birth, are well established by 6 months, and become progressively greater through 24 months. After 2 years the mean smaller head circumference of the Guatemalan children also reflects stunted growth during the first 2 years of life. Similarly, among 5-year-old Guatemalan children of similar stature, head circumference at 5

year of age indicates which of these children were more stunted in stature at 2 years of age. 18 Ref.

Upper arm anthropometric indicators of nutritional status.—Reynaldo Martorell, Charles Yarbrough, Aaron Lechtig, Hernán Delgado, and Robert E. Klein. (INCAP, Guatemala). *Am. J. Clin. Nutr.* 29: 46-53. 1976.

The growth in arm muscle area and arm fat area of preschool children from rural Guatemala is compared to that of a standard from the U.S.A. It was found that although the Guatemalan children have reduced arm muscle and fat areas, the relative reduction in arm fat area was greater than in arm muscle area. Further, the upper arm cross-sectional area of Guatemalan children had proportionately more muscle than fat when compared to that of U.S.A. children. Lastly, for the same body weight, Guatemalan children had a similar arm muscle area but a clearly smaller arm fat area than North American children. It is concluded that these findings suggest that energy rather than protein is the main nutritional problem in these Guatemalan children.

Pulpa y pergamino de café. X. Cambios en la composición química del pergamino de café por efecto de diferentes tratamientos alcalinos.—Beatriz Murillo, Marco Tulio Cabezas y Ricardo Bressani. (INCAP, Guatemala). *Turrialba*, 25, 179-182. 1975.

Two experiments were carried out to determine the effect of different alkaline treatments on the chemical composition of coffee hulls. In the first experiment 12 treatments were applied to 10 g samples of ground and dehydrated coffee hulls. The treatments consisted of adding 50 ml of a 0, 2.5, 5.0 or 10 per cent solution of NaOH, Ca(OH)₂, or NH₄OH at room temperature (20°C) during 24 hours. In the second experiment, to the same weight of coffee hulls, 50 ml solutions of 0, 2.5, 5.0, 7.5 or 10 per cent NaOH at room temperature for 24 hours or at 130°C and 20 psi in the autoclave for 30 minutes were added. All alkaline treatments induced partial hydrolysis of cellular walls, NaOH being the most effective. The higher temperature and pres-

sure in the autoclave did not result in an additional effect on the hydrolysis of cellular walls by NaOH. Analysis of the cellular wall components showed that the partially hydrolyzed compounds were hemicellulose and cellulose while lignin was not affected by the treatments.

Influence of maternal nutrition on birth weight.—Aaron Lechtig, Charles Yarbrough, Hernán Delgado, Jean-Pierre Habicht, Reynaldo Martorell and Robert E. Klein. (INCAP, Guatemala). *Am. J. Clin. Nutr.* 28: 1223-1233. 1975.

This paper discusses some conditions necessary to detect an effect of maternal nutrition on birth weight and the relative contribution of calories and protein to such an effect. The expected dose- and time-response relationships for nutritional interventions aimed at the improvement of birth weight are also discussed. There appears to be a minimal level of nutrients which must be available in order to obtain adequate birth weight. However, above this minimum level, pregnant women can adapt themselves to a wide variety of food intake, both in quantity and quality, without affecting birth weight. The relative contribution of calories and protein to an increase in birth weight depends on the limiting nutrients of the home diet in the population under study. Other factors like physical activity, prevalence of disease and magnitude of the maternal nutritional stores before pregnancy are also important determinants of the relative contribution of calories and protein to birth weight. The anticipated input of a nutritional intervention on birth weight should range between 25 and 84 g of birth weight/10,000 kcal ingested during pregnancy. This estimate was computed from analysis based on four sources of published data: weight gain during pregnancy, prepregnant weight, fetomaternal body composition, and food intake during pregnancy. The expected reduction in proportion of low birth weight (LBW \leq 2.5 kg) babies following a nutritional intervention will depend not only on the estimated range of fetal weight increase but also on the total amount of supplemented calories ingested during pregnancy as well as on the existent proportion of low birth weight babies to the intervention. The offspring of women who have low prepregnant

weight, poor diet, low level of replacement of the home diet by the supplement, low physical activity during pregnancy and good health status will show larger increase in birth weight per unit of supplemented calories. Finally, nutritional interventions during pregnancy as opposed to earlier in the life of the mother, should have the higher impact on birth weight. In consequence, interventions as of pregnancy are recommended. 37 Ref.

Nutritional status and the timing of deciduous tooth eruption.—Hernán Delgado, Jean-Pierre Habicht, Charles Yarbrough, Aaron Lechtig, Reynaldo Martorell, Robert M. Malina, and Robert E. Klein. *Am. J. Clin. Nutr.* 28: 216-224. 1975.

The number of deciduous teeth in a sample of rural Ladino Guatemalan children was counted every 3 months through 24 months of age, and at 6-month intervals from 24 to 36 months. Nutritional status at birth, whether expressed as full-term birth weight or as maternal caloric supplementation during pregnancy, influences the timing of deciduous tooth eruption. Furthermore, the timing of deciduous tooth eruption seems more closely associated with postnatal weight than with birth weight. Although indices of nutritional deficiencies are associated with retarded tooth eruption, the use of mean number of deciduous teeth erupted as an estimate of mean chronological age in population living under conditions of mild-to-moderate malnutrition is relatively accurate because errors of age estimation based on mean values for the present sample only vary between 1 and 2 months. 27 References.

MEXICO

Cristalización de lactosa en suero de leche.—Luis Antonio Ponce-Gómez y Raúl Herrera-Ponce. (Inst. Politécnico Nacional, Apt. 75-839, México 142). *Rev. Tecnol. Aliment.* (México). 10: 107-111. 1975.

Un estudio de la cristalización de lactosa, en suero fresco de leche, pasteurizado y descremado bajo las siguientes condiciones: pH = 4.5 a 4.7; desproteína-

do con ácido clorhídrico; evaporado al vacío a una temperatura de 48 a 52°C, hasta un 57.1 por ciento de sólidos totales; temperatura de cristalización 32°C ± 0.4; con agitación y en nucleación espontánea, dio lugar a la siguiente ecuación empírica:

$$Y = A_0 e^{-A_1/X} \quad (1)$$

Donde: X = Tiempo en horas.

Y = Gramos de lactosa cristalizada por litro de suero original.

$A_0 = 55.022$.

$-A_1 = 0.601$.

Además, por el método clásico cinético químico, se determinó que la reacción es de tercer orden y la constante de cristalización de 0.29.

La intervención del estado en el campo de las subsistencias fundamentales y la tecnología de alimentos.—Enrique Díaz Ballesteros. (Comisión Nacional de Fruticultura, México). *Rev. Tecnol. Aliment.* (México). 9: 288-292. 1974.

Actividades presentes y futuras del codex alimentarius sobre normas alimentarias. Present and future activities of the codex alimentarius work.—Heriberto Barrera-Benítez. (Comisión Nacional de Fruticultura). *Rev. Tecnol. Aliment.* (Méx.) 9: 279-287. 1974.

Dentro de la estructura de la Organización para la Agricultura y la Alimentación (FAO) y con el copatrocinio de la Organización Mundial de la Salud, la Comisión del Codex Alimentarius ha estado dedicada al desarrollo de las Normas Internacionales de alimentos sobre una base mundial, regional o un grupo de países, las cuales eventualmente publicarán normas en un Código de Alimentos que se conocerá como el Codex Alimentarius. Estas Normas tienen como fin el tratar de armonizar las Legislaciones Nacionales sobre alimentos para asegurar una práctica equitativa en su comercio internacional y protege la salud del consumidor, asegurando que se mantengan las debidas precauciones sobre los productos alimenticios.

Trabajando hacia la armonización de las Legislaciones Nacionales de Alimen-

tos, se ve claramente que dentro de estas legislaciones se han establecido diferentes reglamentos y requerimientos, que pueden tener la tendencia a crear dificultades, y algunas veces obstáculos serios sin estar éstos sujetos a una tarifa en el Comercio Internacional de productos alimenticios. Este factor puede ser eliminado fácilmente armonizando las Legislaciones Nacionales sobre alimentos que podrían tener como base las Normas Internacionales aceptadas por la Comisión del Codex Alimentarius. Al establecer Normas Internacionales, deben tomarse las debidas precauciones sobre el hecho de que sean aceptables económicamente y que no sean indebidamente restrictivas desde el punto de vista de productores o fabricantes. Debe darse importancia también al grado en que tales normas pueden ser cumplidas.

Hasta junio de 1974, los miembros integrantes de la Comisión del Codex Alimentarius han estado aumentando constantemente y hasta la fecha 104 países son miembros de la Comisión. Se espera que los países observadores, que han estado colaborando en diversas actividades del trabajo de la Comisión del Codex Alimentarius aumenten en las próximas reuniones de la Comisión. De estos 104 países miembros de la Comisión, 21 son de América Latina, siendo los siguientes: Argentina, Barbados, Bolivia, Brasil, Chile, Colombia, Costa Rica, Cuba, República Dominicana, Ecuador, Guatemala, Guyana, Jamaica, México, Nicaragua, Paraguay, Perú, Trinidad-Tobago, Uruguay y Venezuela.

Enriquecimiento de las tortillas con proteínas de soya por medio de la nixtamalización de mezclas de maíz y frijol de soya.—J. Pérez-Villaseñor, F. R. del Valle y M. Saleme. (Dept. de Bioquímica, Facultad de Química, UNAM). *Rev. Tecn. Alim. (Méx.)* 9: 9-23. 1974. 26 Ref.

VENEZUELA

Sugar as a vehicle for iron fortification.—Miguel Layrisse, Carlos Martínez-Torres, Marta Renzi, Fermín Vélez and Magdalena González. (Instituto Venezolano de Investigaciones Científicas, Apartado 1827, Caracas, Venezuela). *Am. J. Clin. Nutr.* 29: 8-18. 1976.

Sugar as a vehicle for iron fortification presents several advantages over the other vehicles used in the last three decades. In vitro studies demonstrated that ferrous sulfate added to sugar in proportion of 1 mg to 1 g, respectively, is maintained in the ferrous form for a period of at least 1 year and not induce adverse changes in the vehicle. Sugar, by itself, carries practically no inhibitors for the absorption of iron. Iron absorption from fortified sugar mixed with vegetables is the same as that of native vegetal iron. The absorption from fortified sugar is increased more than 50% over that observed from native vegetal when it is administered as a drink during the ingestion of a meal. A further increase in absorption was found when fortified sugar was administered with beverages. The mean absorption ratio of fortified sugar given with orange juice, Coca-Cola, and Pepsi-Cola to a reference dose of iron ascorbate was between 0.45 and 0.66, which is more than 3 times the absorption of this iron fortification mixed with vegetables. The mean absorption ratio from coffee was 0.30, and from coffee with milk, 0.15. These data indicate that the fortification of sugar with iron could be a better procedure for the prevention of iron deficiency than the iron fortification of bread and wheat products, from which iron is poorly absorbed. It could be used in developing countries where beverages are highly consumed by the low socioeconomic class. This program could be extended to all sugar consumption or be restricted to soft drinks.

LIBROS NUEVOS

Underexploited Tropical Plants with Promising Economic Value.—

National Academy of Sciences, Washington D.C. 1975, 188 pág.
Gratuito, pedidos a National Technical Information Service,
Springfield, Va., 22161, U.S.A.

El volumen preparado por un grupo de expertos describe brevemente 36 plantas seleccionadas entre unos 400 que fueron considerados originalmente. Entre ellas se encuentran especies de gran importancia local en Latinoamérica, como son la quinoa, la guanábana y el ñame, mientras que otras son prácticamente desconocidas en nuestro ambiente. Se incluyen cereales, tubérculos y raíces, verduras, frutas, oleaginosas, forrajeras y misceláneos con una breve descripción de las condiciones de cultivo, uso, problemas, áreas de investigación necesaria, bibliografía y personas conocedoras del campo para establecer posibles contactos.

La conquista y colonización de nuestro continente resultó en la introducción de gran número de plantas y animales domésticos, no siempre adaptados a las condiciones ecológicas del nuevo ambiente. A la vez, se llevaron de estas regiones aquéllas que despertaron el interés de los conquistadores: maíz, tomate, papa y muchos más, mientras que otros se quedaron relegados al uso local indígena, sin que se le dispensara la atención necesaria para su adaptación a las condiciones modernas de cultivo y explotación. Muchos de ellos tienen considerable potencialidad como valiosas fuentes de alimentos y de productos exportables, de manera que su estudio y mejora agronómica puede tener repercusiones interesantes. Otros, originarios de regiones asiáticas y africanas podrían tener interés para la racional explotación de zonas

ecológicas con condiciones extremas áridas o muy húmedas.

El volumen ofrece un breve catálogo de una selección de plantas que debería ser estudiado cuidadosamente por agrónomos y planificadores, además que significa una interesante lectura para toda persona interesada en la explotación racional de recursos botánicos.

Werner G. Jaffé

Toxi-Infeciones de Origen Alimentario.—A. E. Olsyna-Marzys, IN-CAP, Guatemala 1975, 414 pág. \$ 10.00.

En ocasión de la celebración del vigésimo-quinto aniversario de la fundación del Instituto de Nutrición de Centro América y Panamá, se organizaron sendas reuniones científicas. El presente volumen recoge las contribuciones de un grupo de expertos invitados en esta oportunidad por el Laboratorio Unificado de Control de Alimentos, fruto de la fusión del Laboratorio Bromatológico del Gobierno de Guatemala y la División de Control y Análisis de Alimentos del I.N.C.A.P.

Se presentaron 23 contribuciones en 5 sesiones que abarcan tanto problemas generales sobre control y enseñanza, como aspectos técnicos específicos de metodología y procedimientos de laboratorio para el estudio de toxinas microbianas, residuos, aditivos y adulteraciones. Cada trabajo está ampliamente respaldado por citas bibliográficas lo que incrementa su respectivo valor y aplicabilidad.

En la literatura en idioma castellano hay una evidente escasez de obras sobre los aspectos de higiene de alimentos, problema de suma importancia para la salud pública que se está reconociendo más y más en nuestros países.

Es, por tanto, altamente satisfactorio contar con una obra sobre toxi-infecciones de origen alimentario de la calidad de la que nos ocupa, porque será sin duda alguna un valioso instrumento en manos del personal responsable, tanto por la planificación como por la labor de con-

trol en el campo de la higiene de los alimentos en los países de habla española.

Werner G. Jaffé

The Rice Report 1975.—Editado por S. Barker, España, H. Mitsuda, Japón y H.S.R. Desikachar, India. Publicado por C.S.I.C. Instituto de Agroquímica y Tecnología, Valencia, España, 179 pág. \$ 20.00.

Esta nueva publicación anual está dedicada a la difusión de los resultados sobre la utilización y tecnología del arroz. Incluye los informes resumidos de numerosas instituciones oficiales y privadas trabajando en los distintos aspectos del uso del arroz.

El primer volumen, correspondiente al año 1975, contiene 88 informes de 32 centros ubicados en 17 países. De esta manera ofrece una revisión de los últimos adelantos en el campo, a la vez que informa sobre las instituciones activas en distintos aspectos de la materia. Una útil y valiosa obra para los profesionales activos e interesados en la tecnología del arroz y sus subproductos.

Werner G. Jaffé

OTRAS PUBLICACIONES

“Situación del cultivo del frijol en América Latina”. Uriel Gutiérrez P., Mario Infante y Antonio Pinchinat. Centro Internacional de Agricultura Tropical, CIAT. Centro Agronómico de Investigación Tropical y Enseñanza, CATIE. Turrialba, Costa Rica, 1975. 33 pág.

“Alternative approaches to meeting basic health needs in developing countries”, a Joint UNICEF/WHO Study. V. Djukanivic and E. P. Mach. World Health Organization, Ginebra. 116 pág. Frs. 24. 1975.

NOTAS

IV CONGRESO LATINOAMERICANO DE NUTRICION

ORGANIZADORES: Sociedad Latinoamericana de Nutrición (SLAN), Sociedad Venezolana de Nutrición (SOVENUT), Instituto Nacional de Nutrición (I.N.N.). Fecha: 21 al 27 de noviembre de 1976.

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PROGRAMA PRELIMINAR

Domingo 21-11-76

- | | |
|----------|------------------------|
| 3-6 p.m. | Inscripción. |
| 7 p.m. | Acto de Instalación. |
| 9 p.m. | Agasajo de Bienvenida. |

V CONGRESO BRASILEIRO DE NUTRIÇÃO E VII CONGRESSO BRASILEIRO DE NUTRICIONISTAS

Porto Alegre, 26 de setembro a 1º de outubro de 1976.
Centro de Convenções da PUCRGS.
Promoção: Federação Brasileira de Associações de Nutricionistas.
Associação Gaucha de Nutricionistas.
Informações e Correspondência
Bureau de Congressos
Av. Venâncio Aires 449, Conj. 8.
Porto Alegre - RS - Brasil.

CONDECORACIONES

Varios destacados miembros de SLAN han sido objeto de honrosos reconocimientos al otorgárseles sendos premios de gran reputación en el gremio de los investigadores en nutrición, a saber:

El Dr. Nevin Scrimshaw, ganador del premio Conrad A. Elvehjem; el Dr. Myron Winick, ganador del premio Osborne and Mendel; y el Dr. Ricardo Bressani, ganador del premio Mc Collum. Para ellos, a nombre de los miembros de SLAN, nuestras más sinceras felicitaciones.

NUEVO DIRECTOR

El Dr. C. Engel renunció al cabo de 18 años como Director del Central Institute for Nutrition and Food Research in Zeist, Holanda.

El nuevo Director es el Prof. Ir. B. Krol.

NOTA IMPORTANTE A LOS SOCIOS DE SLAN

El Volumen XXVI (1976) de ALAN, está siendo enviado a todos los socios de SLAN sin distinguir a los que están al día en sus pagos de cuota de los que no lo están. Esta concesión es solamente por este año 1976, con el objeto de regularizar y hacer más justa la distribución de la revista. Se advierte a los socios que de ahí en adelante únicamente aquellos que estén al día en sus cuotas seguirán siendo incluidos en la lista de suscriptores. El Consejo Directivo de SLAN comunicará a Archivos la lista de aquellos socios que al 30 de noviembre de cada año no hayan cancelado la cuota correspondiente a ese año y no deban, por consiguiente, recibir el volumen del año próximo siguiente. Ejemplo, los que al 30 de noviembre de 1976 no hayan pagado su cuota de 1976, no recibirán el volumen XXVII correspondiente a 1977, y así sucesivamente.

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La Sociedad Latinoamericana de Nutrición (SLAN) fue creada el 10 de noviembre de 1965 en ocasión de celebrarse el Primer Congreso de Nutrición del Hemisferio Occidental. La actual Junta Directiva de la SLAN está constituida por los siguientes miembros:

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Dr. David Picou - Vocal

(Junta Directiva 1975-1976)

Dirección actual hasta el 31 de diciembre de 1976:
c/o Instituto de Nutrición de Centro América y Panamá
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DIRECTORIO DE ARCHIVOS LATINOAMERICANOS DE NUTRICION

Integrado por los Miembros de la Junta Directiva de la Sociedad Latinoamericana de Nutrición

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Comité permanente de la Sociedad Latinoamericana de Nutrición para Archivos Latinoamericanos de Nutrición: Dr. Werner G. Jaffé, Dr. Guillermo Arroyave, Dr. José Félix Chávez y Dra. María Ester Río.

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