

Response of Pre-School Children to high intakes of Haitian cereal-bean mixtures

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SUMMARY

Blends of 70% rice, corn, or sorghum and 30% *Phaseolus vulgaris* have been tested in pre-school Haitian children. No evidence of either acute toxicity or intolerance developing from intakes of as much as 16 weeks was seen. When fed at levels providing 90% of the total protein intake the blends supported highly significant improvements in standard weight, led to corrected serum protein patterns, caused remission of nutritional edema, and improved values for skinfold thickness and internal arm circumference.

BACKGROUND

This is the third report on development of binary mixtures of staple foods indigenous to Haiti suitable for feeding pre-school children. The first (King) (1) described the proximate and amino acid composition of the major cereals and legumes currently grown there. The second (Sirinit *et al.*) (2) dealt with the protein quality and other nutritional potentialities of three such mixtures when studied in the rat. The present report describes the performance of children aged 1 to 5 years when they were fed 90% of their protein and 75% of their calories in the form of enriched rice, corn, or sorghum blends for periods of 6 or 8 weeks.

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Products like Incaparina have a vital role to play in Haiti as in other parts of Latin America, but only in those segments of the population which purchase their food through wholesale food channels. The blends we have been seeking are intended for use in nutrition education in rural Haiti where food is not a part of organized commerce. Although amenable to commercial production they are intended for home preparation.

The target criteria in terms of nutritional quality lie considerably below the comparable figures for Incaparina. This is simply a recognition of the hard facts of life among the Haitian peasantry. The villages described by Beghin *et al.* (3, 4), with endemic nutritional edema in 5 to 10% incidence and 3 to 11% of the pre-school youngsters showing third degree malnutrition according to the system of Gomez, are not unusual. Jelliffe and Jelliffe (5) described a similar nutritional status.

In such communities experience with the rehabilitation centers of Bengoa (6) has been very encouraging as a means toward the public health goal of eradicating kwashiorkor. This goal is one considerably less than that of an optimally nourished population. It is a goal, however, that is concrete and attainable in a foreseeable period of time. The highest aspiration for these mixtures is that they will be able to carry the burden of achieving the eradication of kwashiorkor through maternal education.

The eight target criteria for the mixtures have been the following:

1. ingredients restricted to those common on rural markets,
2. a maximum of two components to simplify teaching of mothers,
3. amenable to current cooking practices,
4. freedom from toxicity,
5. sustained acceptance as major food,
6. 12-15% crude protein of PER 1.7 - 2.0,
7. ability to support reasonable growth,
8. minimum cost.

The data to be presented bear on the closeness with which the three mixtures or blends now available meet these criteria.

EXPERIMENTAL PROTOCOL AND RESULTS

The Blends

Mixtures containing 70% cereal and 30% *Phaseolus vulgaris* (pois rouge) were ground into a coarse flour using ingredients bought in local markets. The flour was then enriched with iron, thiamine, riboflavin, and niacin at double the levels usually employed with wheat flour in the United States. Dicalcium phosphate was added at 3.08 kilograms per ton. Whole cereals and beans were used throughout. Amino acid analyses of anaerobic 6 N HCl hydrolysates were conducted as described by Spackman *et al.* (7). Control hydrolyses at 24, 48, and 72 hours were run to allow correction for losses during hydrolysis. Internal standards of nor-leucine and 3-guanidino-2-amino-propionic acid were run with all samples. The results appear in Table 1.

Proximate analyses yielded the data in Table 2.

TABLE 1
AMINO ACID COMPOSITION OF CORN, RICE, AND SORGHUM
BLENDS WITH 30% PHASEOLUS VULGARIS*

Amino Acid	MILLIGRAMS PER GRAM, OVEN-DRY BASIS		
	Rice blend	Corn blend	Sorghum blend
Lysine	6.76	6.75	6.92
Histidine	3.43	3.94	4.01
Ammonia	2.59	2.80	3.88
Arginine	7.27	5.93	7.29
Aspartic Acid	12.9	13.1	13.3
Threonine	4.36	4.71	4.83
Serine	4.91	5.50	5.91
Glutamic Acid	19.45	22.3	24.2
Proline	6.07	8.70	7.50
Glycine	4.92	6.01	4.77
Alanine	5.56	7.01	8.85
Half-Cystine	0.69	0.48	0.80
Valine	7.06	6.78	7.28
Methionine	1.41	0.91	1.46
Isoleucine	5.60	5.75	6.14
Leucine	9.94	12.8	14.2
Tyrosine	2.23	2.40	3.55
Phenylalanine	6.47	6.63	7.26

* All values are average of duplicate analyses.

TABLE 2
 PROXIMATE ANALYSES OF ENRICHED CEREAL-BEAN BLENDS
 (% OVEN-DRY BASIS)

Component	Rice Blend	Corn Blend	Sorghum Blend
Crude Protein	12.8	15.5	15.9
Crude Fiber	1.7	2.7	2.5
Ash	1.8	2.9	1.7
Ether Extract	0.7	3.7	1.6
Nitrogen Free Extract	83.0	75.2	78.2

Evaluation in Children

Groups of 25 to 30 youngsters between 1 and 5 years old were admitted to a modified Rehabilitation Center of the kind proposed by Bengoa (6). They represented the more poorly-nourished but ambulatory children of Bon Repos, a village about 10 miles north of Port-au-Prince. They were fed three meals each day, six days per week. The menus were designed by a dietician so that 90% of the protein came from the blend under study. All recipes involved at least 30 minutes of cooking at boiling temperature to insure destruction of enzyme inhibitors and other toxins in the beans (Bressani *et al.*) (8). The remainder of the diets consisted of local market foods. The age, sex, and weight of each child were recorded at admission as well as the presence of edema. Each day the exact food consumption was measured and records were entered of fever, diarrhea, and any other health problem. Weights were measured weekly and a re-check for edema was made. On alternate weeks finger-prick blood samples were taken for analyses of albumin and globulin by electrophoresis, and total serum protein. At admission and on discharge hair pigmentation was observed and measurements of skinfold thickness and arm circumference were made.

For purposes of analysis the data from children were discarded if they were absent more than 20% of the time or had fever more than 20% of the time. Otherwise the responses of all youngsters are included in the data presented here.

During the first two weeks each child was examined by a

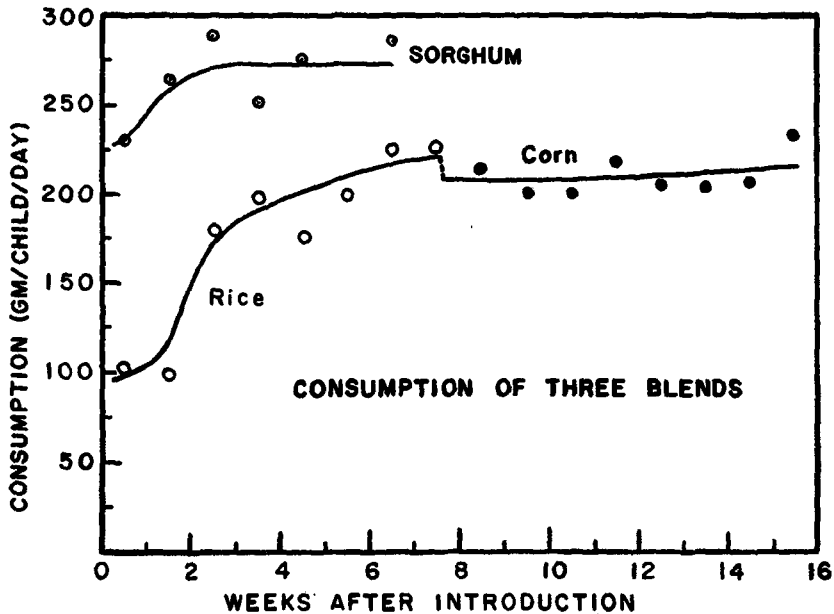
physician daily to detect any indications of toxicity or intolerance.

The first experimental period lasted 8 weeks and tested the rice-bean mixture. These same children were then fed the corn-bean blend for an additional 8 weeks. A new group of children was then started on the sorghum-bean blend for a period of 7 weeks.

RESULTS AND DISCUSSION

At no time was there any indication of toxicity or intolerance. Voluntary consumption, however, did not reach the level of 200 grams per child per day on the rice blends until the fourth week. The extent to which this delay resulted from a flavor or texture problem as distinct from the inexperience of the mothers and the center supervisor with the new recipes, cannot be sorted out. Actual consumption is shown in Figure 1. Once intakes in excess of 200 grams per day had been reached, however, they were sustained. There was no evidence that prolonged feeding led to developing an aversion

FIGURE 1



to the foods among the first group of children who ate the relatively monotonous diet for 16 weeks. When a new group of youngsters was started on the sorghum-bean blend, average intakes in excess of 200 grams per day were seen during the first week and rose to the range of 250 to 275 grams per day over the remainder of the experimental period.

Several characteristics of the children along with data describing attendance, disease-incidence, and meal rejection appear in Table 3. Particular attention is called to the incidence of rejection of meals during the final week of feeding. The rice and corn blends were rejected 8% of time and the sorghum blends 1% of the time. Neither figure is considered greater than is to be expected of normal youngsters offered a more conventional diet.

Food consumption, cost, weight, skinfold thickness, and internal arm circumference data are presented in Table 4. All of the blends supported highly significant improvement in actual weight expressed as percent of standard weight. (Corrections for the increase in standard weight during each experimental period were made.) In addition, skin fold thickness increased, and muscular development as reflected by the measurement of internal arm circumference improved.

TABLE 3
GENERAL DATA ON THE THREE GROUPS OF CHILDREN FED
THE CEREAL-BEAN BLENDS

Observation	Rice blend	Corn blend	Sorghum blend
Number of Children	20	15	21
Age Range, Months	15-61	20-56	12-55
Percent Females	70	73	52
Number Admitted with Edema	7	0	4
Weeks to Remission of Edema ¹	2.5	—	3.2
Days Absent ¹	2.2	2.7	0.9
Days of Diarrhea ¹	2.3	3.0	2.4
Days of Fever ¹	1.8	3.2	0.8
Number of Meals Rejected, last 7 days ¹	1.7	1.7	0.2

¹ Average values.

TABLE 4

CONSUMPTION, COST, AND ANTHROPOMETRIC DATA FROM CHILDREN CONSUMING HIGH LEVELS
OF CEREAL-BEAN MIXTURES

PARAMETER	RICE BLEND		CORN BLEND		SORGHUM BLEND	
	Initial	Final	Initial	Final	Initial	Final
Consumption:						
Grams per child per day	—	178	—	210	—	264
Calories per child per day	—	637	—	738	—	874
Protein, grams per child per day	—	23	—	32	—	39
Cost, cents (U.S.) per child per day	—	4.0	—	2.8	—	2.9
Body Weight Gain, Total in grams	—	983	—	419	—	600
Percent Standard Weight	64.8	70.6**	71.0	73.2**	71.3	75.4**
Skinfold Thickness, mm.	4.7	5.8*	5.5	5.7	4.1	4.9*
Internal Arm Circumference, cm.	12.7	13.4*	13.1	13.5*	12.3	12.8**

*p = 0.05 compared to initial value.

**p = 0.01 compared to initial value.

TABLE 5

RESPONSE OF TOTAL SERUM PROTEIN TO PROLONGED EATING OF CEREAL-BEAN BLENDS
(AVERAGE IN GRAMS/100 ML)

OBSERVATION	Rice Blend	Corn Blend	Sorghum Blend
Initial Total Serum Protein <6.0 gm./100 ml.			
Start	5.0	—	5.1
2 weeks	5.8**	—	5.7
4 weeks	6.1**	—	6.3**
6 weeks	6.4**	—	6.1**
8 weeks	6.6**	—	—
Initial Total Serum Protein \geq 6.0 gm./100 ml.			
Start	6.7	6.8	6.6
2 weeks	6.6	7.0	6.4
4 weeks	6.3	6.7	6.4
6 weeks	6.7	6.9	6.4
8 weeks	6.7	7.0	

*p = 0.05 compared to value at start.

**p = 0.01 compared to value at start.

TABLE 6

RESPONSE OF SERUM ALBUMIN LEVELS TO PROLONGED EATING OF CEREAL LEGUME
BLENDS (AVERAGES IN GRAMS/100 ML)

OBSERVATION	Rice Blend	Corn Blend	Sorghum Blend
Initial Total Serum Protein <6.0 gm./100 ml.			
Start	2.7	—	2.5
2 weeks	3.3	—	3.0
4 weeks	3.5*	—	3.5**
6 weeks	3.3	—	3.2**
8 weeks	3.3	—	—
Initial Total Serum Protein \geq 6.0 gm./100 ml.			
Start	3.8	3.8	3.7
2 weeks	3.5	3.9	3.5
4 weeks	4.1	3.7	3.7
6 weeks	3.4	3.9	3.8
8 weeks	3.6	3.9	—

**p = 0.01 compared to starting value.

*p = 0.05 compared to starting value.

King *et al.* (9) showed that rural youngsters like those studied here would have been expected to gain 308 grams during a 8 week trial and 270 grams during a 7 week trial. The actual gains (Table 4) were 983 and 419 grams on the rice or corn diets (8 weeks) and 600 grams on the sorghum diet (7 weeks).

About half of the children studied entered the trials with markedly depressed total serum protein concentrations (<6.0 gm./100 ml.), and depressed serum albumin levels (<3.0 gm./100 ml.). That these values rose into the normal ranges on eating the blends and that youngsters starting with normal values maintained their status is shown by the data in Tables 5 and 6.

In the relatively brief feeding periods reported here significant changes in hair pigmentation did not appear, but the marginal hair did become noticeably less easily plucked.

DISCUSSION

Judging these blends against the criteria set up as targets, they appear to be adequate. It is important to keep in mind that their main purpose is to serve as basic foods for the pre-school child in educating peasant women. Capitulating to the economic strictures on these women, it appears necessary to set up as the limited objective of present nutrition education the elimination of kwashiorkor and marasmus. The desirable goal—a nation of optimally nourished Haitian youngsters—is simply not a goal that can be envisioned by reasonable men within the decade.

Without apologizing for this acceptance of an objective so far short of what might be hoped, it is fair to point out that the eradication of any infectious disease such as yaws, small-pox, or malaria is only a partial step toward a healthy nation. Perhaps we as nutritionists need to adopt the highly successful public health tradition of eliminating diseases from a population one at a time starting with the most severe.

The order of attack in one country might be kwashiorkor, keratomalacia, marasmus, endemic goiter, nutritional anemia, beri beri, and obesity. In another country quite a different order would be necessary. The point is that in many nations

any attempt to combat all forms of malnutrition simultaneously is similar in complexity to a public health attack on all infectious diseases at once. Either program would be doomed to failure in almost any contemporary nation.

Protein-calorie malnutrition being the most prevalent fatal nutritional disease in Haiti today, deserves first attention. Through a network of nutritional rehabilitation centers using these blends as the core of maternal nutrition training, it is our opinion that protein-calorie disease can be educated out of existence in Haiti even within the present limited and inefficient food production.

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