PN-AAZ-806
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CONSUMPTION AND DIGESTION OF CASSAVA BY SMALL CHILDREN

Project Report: 1 July - 31 December, 1983

1.0 Preliminary Studies:

Preliminary studies were initiated to compare the tolerance to and digestibility of peeled, boiled and mashed fresh cassava ("yuca sancochada") with the same parameters as for cassava that was processed identically and then oven dried to cassava flour.

1.1. Subjects:

Four male children 12, 13, 22 and 23 months of age were included in the studies. All had previously recovered from severe protein energy malnutrition and had reached a late stage of recovery with weight for length between the 10th and 30th percentile of the NCHS reference population and serum albumin concentrations between 3.86 - 4.16 g/dl. None had evidence of intestinal malbsorption during previous metabolic studies, and all were gaining weight satisfactorily.

1.2. Sequences of Studies:

The studies consisted of two nine-day periods, one with boiled, fresh cassava and one with cassava flour. In all cases the cassava flour was given during the second diet period.

1.3. Diets:

In order to prepare the two diets, cassava ("yuca") was purchased daily from the local market in amounts sufficient for two days of consumption for each of the two children studied simultaneously. The cassava was peeled and cooked in boiling water for 30 to 45 minutes: Once boiled, half of the cassava was used during the first diet period; the remainder was stored frozen and later oven dried in order to prepare the cassava flour. On the seventh day of the first diet period enough cassava was boiled for the last three days of both diet periods. On the same day all the boiled cassava that had been stored for the preparation of flour, as well as half of the cassava boiled on that day was taken to the Instituto Nacional de Desarrollo Agroindustrial (INDDA) for oven drying. The boiled cassava was cut into pieces and dried at 45°C for 20 hours and then was ground into a flour.

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During the second diet period, the diets were prepared daily from the cassava flour by boiling in water for five minutes. During both diet periods the complete diets were prepared by blending the cooked cassava mixture with "Casec" (calcium caseinate), vegetable oil (50:50 cottonseed oil; soy oil), sugar (sucrose), and dextrimaltose. Finally, a mixture of vitamin and minerals sufficient to provide the daily requirements as proposed by the Food and Nutrition Board of the U.S. National Research Council, was added to the blended diets.

Both diets were formulated so that cassava provided 50% of the total energy and approximately 10% of the total protein. Considering the final composition of the diet, protein supplied 8% of the energy with all of the non-cassava protein supplied by casein. Twenty percent of energy was provided as fat and the remainder (72%) as carbohydrates.

1.4 Laboratory Analyses:

Aliquots of each day's diet were separated for subsequent laboratory analysis of proximate composition.

Hydrocyanic acid was determined in raw, boiled and dried cassava.

Wet and dry weight of feces were determined.

Blended aliquots of the quantitative fecal collections were measured for total fats (Van de Kamer), total energy (bomb calorimetry), nitrogen (Kjeldahl), and carboydrates by difference. The nitrogen concentration in urine was also determined.

Serum total protein (Biuret), albumin (electrophoresis) and hematocrits were measured in blood at the beginning and end of each diet period.

1.5 Results of the Preliminary Studies:

a) Table 1 shows the ingredients and nutrients included in a calculated diet for both boiled and oven-dried cassava

For the first two children in the study, the diets were formulated on the basis of published data regarding the composition of fresh "yuca" (Tabla de Composición de Alimentos Peruanos) or of dried "yuca" as prepared previously by INDDA. The diets for the second group of two children were formulated on the basis of the analyses of the diets prepared for the first two children.

b) Table 2 shows the energy and nitrogen contents as calculated and as analyzed.

Based on analysis of the cassava, it was found that the energy content of the diets actually received by the first two children differed from the calculated contents by -9.1%. for the boiled cassava, whereas there was no difference for the oven-dried cassava. The actual energy content of the diets for the last two children agreed more closely (+ 3.4%) with the calculated content for the boiled cassava; again, there was no difference between the analyzed and calculated oven-dried cassava. The actual nitrogen content of the diets differed from that of the calculated diets by + 4.2 and -6.8% for the boiled cassava for the first and second group of children respectively, and by +6.7 and -7.5 % for the oven-dried cassava.

c) A summary of results for energy intake, nitrogen balances, digestibility and tolerance of the diets, and weight gain of the children is presented in Table 3 for both diets.

Energy intake from the cassava-flour diet (115.6 Kcal/kg/day) was slightly greater than from the boiled cassava diet (111.5 kcal/kg/day), but the difference was not statistically significant.

The slightly greater amount of nitrogen consumed with cassava flour (3325 mg/day) was significantly different from the amount consumed with boiled cassava (3158 mg/day, $P<0.05$).

The apparent absorption of nitrogen from the boiled cassava diet (83.4% $\pm$3.1) was, however, significantly higher than the apparent absorption from the cassava flour (78.6% $\pm$2.8, $P<0.05$). On the other hand, apparent nitrogen retention was higher from the cassava flour (35.6% $\pm$10.0) than from the boiled cassava (31.1% $\pm$7.7, $P<0.05$).

All parameters of carbohydrate digestibility, including fecal wet and dry weight and fecal energy excretion, indicated that the boiled cassava diet was more readily digestible. There was no difference in the absorption of fat from the two diets.

d) Tolerance of the diets was variable. The first two children tolerated the diets better than the last two and there was no difference in the amount of time required to consume their portions (6.6 and 4.8 minutes for the boiled vs 5.8 and 5.1 minutes for the oven-dried cassava). The second pair of children required more time to finish their portions than the first pair and also ate the diet composed of cassava flour more slowly than the diet composed of boiled cassava (18.6 and 21.1 min) vs 11.8 and 12.3 min, respectively).

1.6. Discussion:

Wet and dry weight of feces as well as energetic content in stools consistently greater in patients receiving oven-dried cassava suggests a minor digestibility than in patients receiving boiled cassava. The lower gain weight in children receiving oven-dried cassava confirms this assumption. We assume that a retraction of the starch is produced by the oven drying process preventing its absorption.

A Maillard reaction might be happening

Since the difference between these two processes in these parameters are not significant, we are including two more children in these study. An alternative to solve this problem is to freeze-dry the entire amount of the cassava for the next study, process that is available in private industry in Peru.

2.0 Hydrocyanic Acid in Cassava:

The content of cyanide in the boiled cassava as well as in the cassava flour was determined at INDDA. A semiquantitative method (Magnin) was used; the cyanide detection limit is 5 mg/kg of cassava.

The results are shown in Table 4. For most samples no cyanide was detected. For two samples of the boiled cassava traces ($<$ 5mg/kg) were found.

With regard to acute toxicity a content of less than 50 mg HCN/kg fresh peeled tuber is regarded as innocuous.

Thus the control of hydrocyanic acid in the cassava used in the study seems very low.

3.0 Program for psychological stimulation of patients in IIN.

Beginning December 1, 1983 a graduate from the psychology department of the Universidad Mayor de San Marcos has been employed for psychological stimulation of children hospitalized in the IIN. She is actively organizing a play therapy program and is developing a separate playroom within the metabolic unit.

Additionally, preliminary discussions have been held with three pediatric psychiatrists from the National Institute of Mental Health (Instiuto Nacional de Salud Mental Honorio Delgado-Nogushi) to examine the possibility of developing a broader and more detailed program for psychological stimulation of the patients. This would involve the participation of the staff of the metabolic unit as well as the families of the patients. The psychiatrist would serve as consultants to the program and would attempt to evaluate its impact.

Enrique Morales, M.D.
Co-Investigator

TABLE I

CASSAVA DIETS

Ingredients	Amount	K cal	Prot. gm	N_2 mg	Fat gm	H.Co gm	Na mEq	K mEq	Cl mEq
Boiled *	100	150	0.5	80	0.2	36.4	0.41	4.1	0.82
Boiled cassava	33.34	50.01	0.167	26.67	0.07	12.14	0.14	1.37	0.27
Casec	2.13	7.73	1.836	293.79	0.04	-	0.05	0.02	-
Veg. oil	2.41	19.09	-	-	2.12	-	-	-	-
Sugar	2.90	11.60	-	-	-	2.90	-	-	-
Dextrim	2.99	11.60	-	-	-	2.90	0.09	0.01	-
Mineral Mix	1.533	-	-	-	-	-	1.72		1.72
K Cl	1.59	-	-	-	-	-	-	1.59	1.59
TOTAL		100.03	2.003	320.46	2.23	17.94	2.00	3.00	
% of Kcal		100	8		20	72			
Oven-Dried Cassava **	100	352.9	1.47	235.2	1.78	82.75	3.71	13.7	2.76
Ov.D.Cassava	14.17	50.01	0.21	33.33	0.25	11.73	0.53	1.94	0.39
Casec	2.08	7.55	1.79	286.90	0.04	-	0.06	0.02	-
Veg. oil	2.21	17.50	-	-	1.94	-	-	-	-
Sugar	3.12	12.48	-	-	-	3.12	-	-	-
Dextrim.	3.22	12.49	-	-	-	3.12	0.10	0.01	-
Mineral Mix							1.31		1.31
K Cl	1.03							1.03	1.03
TOTAL		100	2.00	320.23	2.23	17.97	2.00	3.00	2.73
% of Kcal		100	8		20	72			

* Values from the Tabla de Composición de Alimentos Peruanos.

** Values from the analysis of cassava from the town of Mala.

TABLE 2

CASSAVA DIETS

	PATIENT I.I.N.	NITROGEN CONTENT CALCULATED (mg/day)	NITROGEN CONTENT ANALYZED (mg/day)	ENERGY CONTENT CALCULATED (Kcal/kg/day)	ENERGY CONTENT ANALYZED (Kcal/kg/day)
BOILED CASSAVA	1	3459	3609 (104.3%)*	115	104.5 (90.9%)*
	2	2765	2878 (104.1%)*	120	109.1 (90.9%)*
	3	3320	3095 (93.2%)*	125	129.2 (103.4%)*
	4	3271	3049 (93.2%)*	100	103.4 (103.4%)*
	$\bar{X}$	3203.75	3157.75 (98.6%)	115	111.55 (97%)
	DS	± 303.15	± 314.99	± 10.8	±12.02
OVEN-DRIED CASSAVA	1	3607	3849 (106.7%)*	115	114.9 (99.9%)*
	2	2875	3069 (106.7%)*	120	120.0 (100. %)*
	3	3561	3295 (92.5%)*	125	126.5 (101.2%)*
	4	3337	3089 (92.6%)*	100	101.2 (101.2%)*
	$\bar{X}$	3345	3325 (99.4%)	115	115.65 (100.6%)
	DS	± 334.8	± 363.64	± 10.8	±10.74

* Values in parentheses are calculated percentages: $\frac{\text{analyzed} \times 100}{\text{calculated}}$ %

TABLE 4

RESULT OF HYDROCYANIC ACID ANALYSIS*(mg / kg)

DIET		Boiled - Cassava			Oven - Dried - Cassava		
Study day		1 2 3	4 5 6	7 8 9	10 11 12	13 14 15	16 17 18
Sample N°		1	2	3	4	5	6
IIN N°	Group						
780 781	A	-	5	Neg.	Neg.	Neg.	Neg.
779 791	B	Neg.	Neg.	5	Neg.	Neg.	Neg.

* MAGNIN semiquantitative method adapted to cassava.

TABLE 3

BOILED (*) VS. OVEN-DRIED (**) CASSAVA

Patient I.I.N.		K Calories /Kg/day	NITROGEN Intake mg/day	NITROGEN % Alb.	Ret.%	FECES Wet Weight g/day	FECES Dry Weight g/day	FECES Fat g/day	FECES Calories	Δ Body Weight g/day	TOLERANCE Minute/Food
780	(*)	104	3609	88	29	99	17.07	1.48	57.7	(57.8)	6.55
	(**)	115	3849	83	32	191	23.99	1.37	81.6	(53.3)	5.80
781	(*)	109	2878	80	24	194	18.17	1.10	62.7	(26.0)	4.8
	(**)	120	3069	78	27	227	21.35	1.05	72.9	(29.0)	5.1
779	(*)	129	3095	83	42	164	18.33	0.82	65.1	(61.0)	12.3
	(**)	127	3295	76	50	173	23.24	1.55	91.1	(33.0)	21.1
791	(*)	103	3049	83	30	227	19.40	1.10	72.68	(41.0)	11.8
	(**)	101	3089	78	34	289	18.01	1.32	76.5	(- 21.0)	18.6
$\overline{X}$	(*)	111.5	3157.7	83.4	31.1	170.9	18.24	1.12	64.5	(46.4)	8.9
SD		±12.03	±315.0	±3.1	±7.4	±54.3	± 0.95	± 0.27	± 6.24	± 16.4	± 3.75
$\overline{X}$	(**)	115.6	3325.5	78.6	35.6	219.8	21.7	1.32	80.5	(38.5)	12.7
SD		±10.76	± 363.6	± 2.8	±10.0	± 50.9	± 2.66	± 0.21	± 7.89	± 13.0	± 8.38
Δ %		+ 3.7	+ 5.3	- 5.8	+14.5	+ 28.6	+ 19.0	+ 17.7	+ 24.8	- 17.0	+ 42.7
P (based on paired t test)		NS	< 0.05	< 0.05	< 0.05	NS	NS	NS	NS	38.5	NS

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CASSAVA: CONSUMPTION AND DIGESTIBILITY BY SMALL CHILDREN

SECOND REPORT: JAN 01,84 - JUN 06,84

1.0 PRELIMINARY STUDY BOILED VS OVEN-DRIED CASSAVA

In the first two months of the year we completed the last part of the preliminary study of digestibility of boiled Cassava, compared to oven-dried cassava in six children recovered from protein, energy malnutrition, with the following results:

The digestibility parameters of carbohydrate and protein have more or less followed the same trends as with the first four patients in the study; the caloric intake was the same for both diet groups, (with boiled as well as with oven-dried cassava). In table 1 we can see that nitrogen absorption was greater during the boiled cassava period. The percentage of nitrogen retained from oven-dried was 16% greater than from boiled cassava. With respect to carbohydrate digestibility Fecal CHO excretion and fecal wet weight were 13 and 24% greater, respectively, from oven-dried cassava ($p < 0.05$). Fecal dry weight and fecal energy were greater during th period of oven-dried cassava but the difference was not statistically significant. The fat content in feces was 20% greater during the oven-dried cassava period; the difference was not statistically significant.

The increase in body weight was greater during the period of boiled cassava than during the period of oven-dried cassava, but the difference was not significant statistically.

Serum albumin increased 0.15 g/dl during the boiled cassava period, and decreased 0.14 g/dl during the oven-dried; the difference between the 2 periods was not statistically significant.

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The time interval between starting and finishing a feed was taken to infer "diet tolerance" (less time = more tolerance). On the average, the time interval per feeding during the oven-dried period was 29% greater than in the boiled-cassava period. The difference was not statistically different, suggesting no difference in "diet tolerance".

The greater fecal wet weight and the greater "loss" of CHO suggests a lower digestibility of the oven-dried cassava. The other parameters though not statistically significant, corroborate this conclusion.

2.0 FIRST STUDY EFFECT OF DIET BULK ON DIGESTIBILITY

Following the methodology described in the study project, we prepared four diets, three from cassava, (purchased fresh in one lot and then lyophilized), and a control diet based on casein. Lyophilization (freeze-drying) was done to conserve the chemical characteristics of the nutrients.

Table 2 shows the diets ingredients. Cassava provided 25,50 or 75% of the total energy, and 4.5, 8.5 or 12.9% of the protein, respectively.

Casein was added to each diet to bring the total protein to 8% of calories, the same percent provided from the control diet. All the diets were isocaloric and isoenergetic.

Table 3 shows the distribution of selected nutrients per 100 Kcal.

All children had four casein periods, interfaced by three cassava periods.

The first three days in each casein period were for "adaptation"; metabolic collections were completed during days, four to nine in casein period 1, and 4-6 in casein periods 2 through 4.

The cassava periods were each 9 days, the first 3 days for adaptation, the next 6 for metabolic collection. Sequences of % of Kcal provided from cassava were alternated in six combinations.

According to the protocol, so far we have completed the study in three children (table 4), nitrogen absorption and retention was less during the periods of 75% cassava diet. Fecal dry weight, wet weight, fecal energy and carbohydrate increase as the percentage of energy from cassava increases.

Less weight was gained during the cassava than during the control periods. Furthermore, weight gained during the 50% cassava was less than during 25 or 75%. During the 75% period serum albumin levels tended to decrease.

Individual feedings lasted, on average, 4.2,5.9 and 8.8 minutes for the 25, 50 and 75% periods, vs.4.0 or 4.6 minutes for the control diets. This suggests a decreased tolerance of higher levels of cassava.

The number of childrens is very low so we can not get significant differences however, the trends of the stool parameters suggests lower digestibility of carbohydrates with 75% of energy from cassava. The apparently reduced tolerance to this higher level of cassava, as well as the lower levels of serum albumin, support this suggestion.

3.0 BREATH HYDROGEN DETERMINATIONS

Breath hydrogen determinations were made in children during metabolic collections of each cassava period and in the initial casec period. Lactulose control experiments were also performed in each child before beginning the study.

On two occasions breath samples were collected for 6 1/2 hours, with a second cassava meal being given after the 180 min.sample.

Three parameters were used to characterize the breath hydrogen excretion data:

a). basal value, the breath hydrogen measure taken inmediately before the meal was eaten;

b). peak rise, the difference between the highest post-prandial hydrogen value and the basal value; and

c). time required to reach the peak.

These parameters were compared with the fecal CHO excretion data obtained during metabolic collections.

The lactulose test resulted in a marked increase (> 20 ppm) in the breath hydrogen concentration, with the time of peak rise between 120 and 150 min (table 5).

The hydrogen concentration in the basal samples (table 6) increased with increasing cassava consumption; and the highest values were seen during the 75% diet period.

Also the peak rise (table 6) decreased when cassava intake was increased; during the 75% diet period there was no breath hydrogen excretion increment in any of the three patients.

The minimal time required to achieve the peak rise was 70 min (table 6); in the patient whose breath samples were collected up to 6 1/2 hours, the peak rise was at 375 min from the first meal intake (table 7).

The fecal CHO excretion increases with increasing calories in the cassava diet, the lowest value corresponds to the casein-sucrose diet (table 7).

A tendency to ward a linear relation between fecal CHO excretion and basal hydrogen excretion was noted (Fig. N°1).

The basal samples taken the same day from the same fasting patient seems to decrease as time of feeding approaches (table 8).

If we take the mean of these basal values and then calculate the mean of these means, for each diet period, we can see an increase of hydrogen excretion with increasing cassava calories in comparison with the lowest values for casein-sucrose diet.

4.0 HYDROCYANIC ACID IN CASSAVA

The content of cyanide in the lyophilized cassava (a white cassava batch from the jungle of Perú) was determined at the IIN. A quantitative method of AOAC was used.

RESULTS:

HCN in lyophilized cassava was 47 ppm equivalent to 10-15ppm in boiled cassava.

5.0 STIMULATION PROGRAM FOR UNDERNOURISHED CHILDREN

Mrs. Medina, the play therapist we hired last december, 1983, together with Dr. Maureen Black, a visiting psychologist from the University of Maryland, have developed a Stimulation Program for Undernourished Children. For this purpose they used the: "PROGRAMA INTEGRAL DE ESTIMULACION TEMPRANA CON BASE EN LA FAMILIA" (PIETBAF),("EARLY INTEGRAL ESTIMULATING PROGRAM BASED ON THE FAMILY"), developed by the "Instituto Nacional de Investigación y Desarrollo de la Educación" (INIDE) as a basis for both the evaluation procedure and program recomendations.

The play therapist maintains an individualized program for each child recovering from PEM. Additionally, she has had the opportunity to provide a baseline of Knowledge about child development and stimulation activities to the nurses and aids staff.

Luis M. Arce

P/ Enrique Morales Moreno, M.D.
Medical Director

BALANCE STUDIES: CRITERIA FOR PARTICIPATION

- SMALL CHILDREN CONVALESCENT FROM PEM
- PAST THE INITIAL PHASE OF RECUPERATION
- EATING FULL DIET WITHOUT MALABSORPTION
- STEADY WEICHT GAIN ESTABLISHED
- WEIGHT FOR HEIGHT $\geq$ 10th PERCENTILE NCHS
- SERUM ALBUMIN $\geq$ 3.6 g/dl
- NO SIGN OF SPECIFIC NUTRIENT DEFFICIENCY
- FREE OF INFECTION AND INTESTINAL PARASITES

TABLE 1

DIGESTIBILITY OF BOILED AND OVEN-DRIED CASSAVA IN SIX CHILDREN RECOVERED FROM ENERGY - PROTEIN MALNUTRITION

NITROGEN BALANCE	BOILED CASSAVA $\bar{x}$	OVEN-DRIED CASSAVA $\bar{x}$
% Absorption	83	80
% Retention	33	38*
CALORIES		
Intake Kcal/Kg/day	112	112
FECES		
Wet weight g/day	172	214*
Dry weight g/day	20.2	22.4
Fat		
g/day	1.0	1.2
% Intake	4.4	5.2
Energy		
Kcal/day	72	83
% Intake	6.9	7.6
CHO		
g/day	10.4	12.2*
BODY WEIGHT: Δ g/day	47	32
SERUM ALBUMIN : Δ g/dl	0.15	-0.14
TOLERANCE min/feeding	10.6	13.7

* $p < 0.05$

TABLE II

DIETS INGREDIENTS AT THREE ENERGY INTAKE LEVELS FROM CASSAVA AND CONTROL DIET: VALUES PER 100 K CALORIES

		CASSAVA			CASEC
Cassava :	Energy	25%	50%	75%	Control
	Protein	4.5%	8.5%	12.9%	-
	Amount (g)	6.71	13.41	20.11	-
Ca Caseinate	g	2.23	2.13	2.03	2.32
Oil	ml	2.43	3.29	2.23	2.39
Sucrose	g	5.96	5.83	-	6.08
Corn Syrup Solids	g	6.14	-	-	6.27
Starch	g	-	-	-	6.79
Min. mix	g	0.7815	0.7815	0.7815	0.7815
K Calories		100	100	100	100

TABLE 3

NUTRIENTS IN CASSAVA AND CONTROL DIETS

VALUES PER 100 K CALORIES

		Total/100 Kcal	Conversion factors (Kcal/g)	Kcal %
PROTEIN	(g)	2.0	4	8.0
FAT	(g)	2.22	9	20.0
CHO	(g)	18.0	4	72.0
Na	mEq	2.5	-	-
K	mEq	3.1	-	-
VIT.min		≥RDA*	-	-

* RDA,FAO/WHO 1983

TABLE IV

DIET DIGESTIBILITY PARAMETERS IN THREE ENERGY INTAKE LEVELS FROM CASSAVA AND CONTROL DIET (PARTIAL RESULTS, 3 CHILDREN)

	25%			50%			75%		
	Control	Cassava	Control	Control	Cassava	Control	Control	Cassava	Control
NITROGEN									
% Absorption	81	80	79	79	78	82	84	72	80
% Retention	32	32	50	50	34	41	43	25	29
FECES									
Wet weight (g/day)	90	138	98	98	212	106	85	264	117
Dry weight (g/day)	16.84	17.21	16.28	16.28	23.6	18.5	16.47	31.8	20.17
Energy :									
Kcal/day	52	60	58	58	84	63	56	122	61
% Intake	6.0	6.3	5.8	5.8	8.6	5.6	5.1	12.5	4.1
Fat (g/day)	1.77	1.77	2.45	2.45	1.24	2.28	2.5	2.51	2.19
% Intake	9.0	8.6	11.6	11.6	5.6	10.4	11.9	11.7	9.8
Carbohydrates (g/day)	3.85	5.2	2.8	2.8	11.5	4.9	3.7	14.6	4.1
BODY WEIGHT Δ									
g/day	42	30	33	33	23	48	57	28	38
g/Kg/day	5.2	3.4	3.9	3.3	2.7		6.5	3.3	4.3
Δ SERUM ALBUMIN	-0.05	0.04	-0.05	-0.05	0.29	-0.36	-0.01	0.27	-0.05
TOLERANCE min/feeding	4.6	4.2	4.3	4.3	5.9	4.0	4.15	8.8	4.2

TABLE 5

Breath Hydrogen Concentration (ppm) in Children Following a Single Dose of Lactulose

Time after ingestion	Breath Hydrogen Concentration (ppm)[a] Patient N°		
	827[b]	825[b]	842[c]
Basal	11.1	53.2	18.3
30	11.1	39.1	31.1
60	28.1	63.5	64.7
90	59.9	94.6	99.5
120	69.5	141.2	134.8
150	63.6	105.3	139.4
180	65.1	76.1	91.4
peak rise (ppm)	58.4	88.0	121.0
time of peak rise (m)	120	120	150

- a Each value represents the mean of two determinations
- b Dose of lactulose = 6.7 g (10% w/v)
- c Dose of lactulose = 3.3 g (10% w/v)

TABLE 6

Breath Hydrogen Excretion and Fecal CHO Excretion by Children Consuming Casein-Sucrose or Different Levels of Cassava

	Patient N°	Casec Period	Cassava Period 25%	50%	75%
Breath Hydrogen Excretion					
a. Basal Value (ppm)	827	12	28	12	15
	825	14	11	13	20
	842	8	8	18	22
	Mean	11	16	14	19
b. Peak Rise (ppm)	827	10	2	2	(-)
	825	0.8	(-)	(-)	(-)
	842	11	5	0.2	(-)
	Mean	7	2	0.7	(-)
c. Time of Peak Rise (min)	827	210	30	150	0
	825	30	0	0	0
	842	180	180	180	0
	Mean	140	70	110	0
Fecal CHO Excretion (% of Intake)	827	2.6	3.1	7.2	8.6
	825	1.8	3.0	5.7	9.6
	842	2.7	3.4	6.8	9.0
	Mean	2.4	3.2	6.6	9.1

TABLE 7

Breath Hydrogen Concentration in Samples Collected up to 6 1/2 Hours Following Meals of Cassava (50% and 75% of Total Energy Intake)

Patient N° 342

Time after ingestion (min)		Breath Hydrogen Concentration (ppm) Sample N° 1-50%	Sample N° 2-75%
	Basal	21.7	10.4
1st. Meal	30	14.1	11.0
	60	9.7	11.0
	90	10.5	9.1
	120	12.1	11.3
	150	16.9	9.7
	180	12.9	-
2nd. Meal	240	20.5	9.5
	310	20.9	12.0
	375	25.7	18.5
peak rise (ppm)		8.1	4.0
Time of peak rise (min)		375	375

TABLE 8

Variations in Breath Hydrogen Concentrations (ppm) of a Fasting Individual Consuming Casein-Sucrose or Different Levels of Cassava on the Day Prior to Breath Collection

Patient Nº 842

Time of Collection in relation to first meal of day (min)	CASEC DIET	CASSAVA DIET					
		25%		50%		75%	
- 90	8.5	6.3	12.4	12.7	25.7	39.5	23.3
- 60	-	-	-	13.5	20.5	33.0	-
- (45-30)	7.1	8.1	8.3	-	21.7	-	-
0	-	-	-		-	-	10.4
Mean	7.8	7.2	10.4	13.1	22.6	36.2	16.8
Mean/Diet period	7.8	8.8		17.8		26.5	

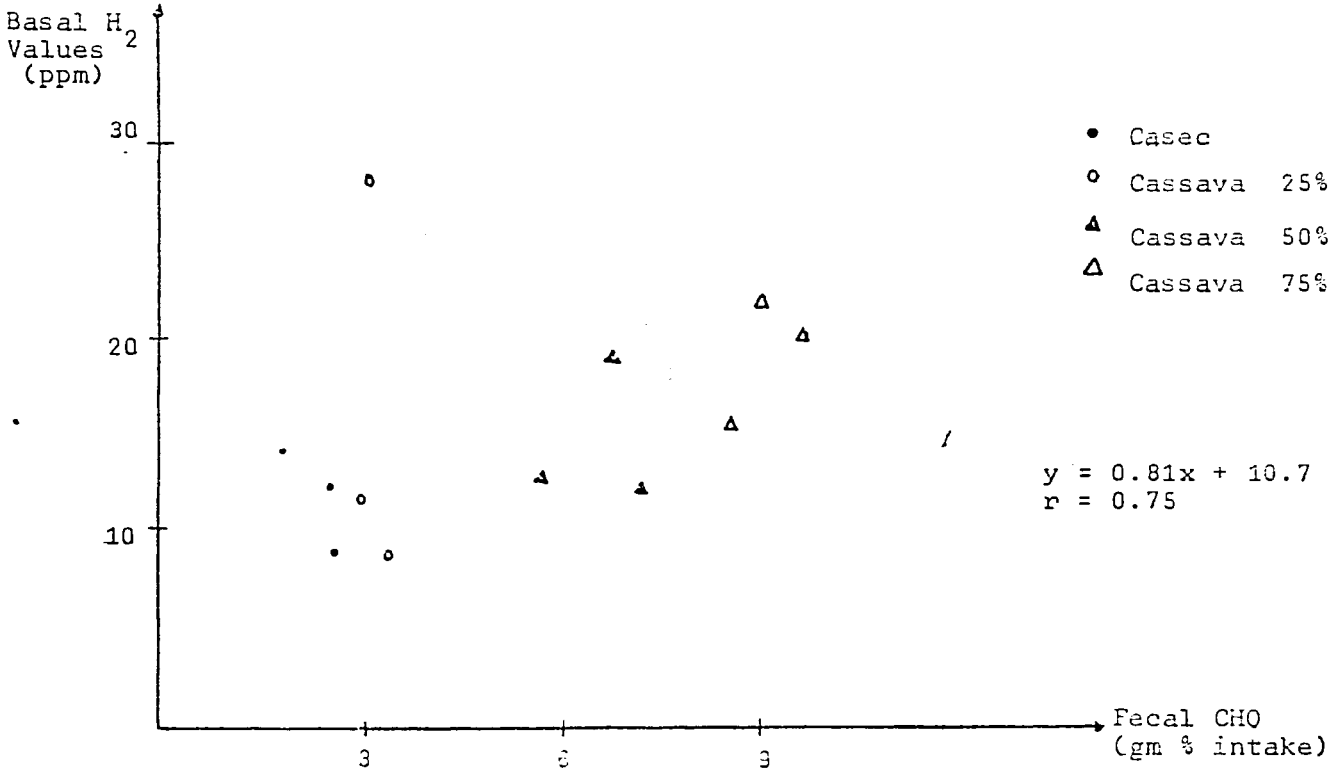

FIGURE 1. Fecal CHO Excretions Compared Linearly with Basal Breath Hydrogen Values in Three Subjects Consuming Casein-Sucrose or Different Levels of Cassava

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CASSAVA: CONSUMPTION AND DIGESTIBILITY BY SMALL CHILDREN

(THIRD REPORT to AID, covering period 1st. July - 31st. Dec., 1984)

During this period of the contract, the First Study in which the consumption, digestibility, and protein quality of three standarized diets containing three levels of cassava were compared - was completed. The following report therefore details the results of the study.

1.0 Methods - The methods were presented in detail in the original protocol, thus only a brief review will be presented herein.

1.1 Diets: A fresh batch of cassava from the Peruvian jungle was lyophilized in order to provide a single homogenous lot sufficient to meet the needs of the study. Three study diets containing 25, 50, and 75% of energy as cassava were compared with a control diet in which the carbohydrate source was a mixture of sucrose and dextrimaltose, vegetable oil (soybean : cottonseed, 1:1) provided 20% of energy in all diets. The major protein source was calcium caseinate, and the protein provided 8% of energy.

In the "25", "50", and "75" cassava diets, cassava provided 4.5%, 8.5%, and 12.9% of the protein respectively; all of the protein in the control diet was derived from casein, vitamin and mineral supplements were added to meet the US' RDA's.

Each child received the cassava diets during three nine - day periods. A nine - day period with the control diet preceeded the first study period; this period was followed by a six - day period with the control diet, and all subsequent cassava diets periods were preceeded and followed by six - day periods in which the control diet was given. The order of the cassava diet periods was randomized among different patients.

1.2 Study subjects: Eight male infants between 20 and 38 months of age were included in the study, all were recovering from severe malnutrition, but had achieved at least 10th. percentile of NCHS reference of weight for length, serum albumin >3.5g/dl, and had demonstrated normal intestinal absorption of a casein, sucrose - vegetable diet before inclusion in the present studies. The clinical characteristics of these subjects are summarized in Table 1.

2.0 Results -

2.1 25% of dietary energy from cassava (Table 2).

The mean apparent absorption of nitrogen was similar during the cassava dietary period and during the preceeding and following control periods. The apparent nitrogen retention, however, was lower during the cassava period than during the control periods. Nitrogen retention during the latter control period was statistically significantly greater than during the cassava period.

Although the children gained slightly less weight during each successively higher level of cassava consumption, these differences were not statistically significant. As the amount of cassava in the diet increased, the children required progressively greater periods of time to consume their feedings.

3.0 Discussion:

These studies provide the first quantitative information on the digestibility and nutritional quality of cassava - containing diets for infants and young children. All results are compared with a control diet known to be highly digestible and of superior nutritional quality. The apparent absorption and retention of nitrogen deteriorated moderately with successive increases in the amount of cassava consumed. Although most of the fall in nitrogen retention could be explained by the reduced absorotion, the biological value of the protein also tended to decrease very slightly. These results were unexpected since the vast majority of the protein in the study was provided by casein, which is a high quality reference protein source. Although the amount of protein provided by cassava increased slightly with each increment in the proportion of dietary energy provided by cassava, this small change in protein source cannot explain the observed differences in absorption and retention. Apparently some factor present in cassava interfered with the utilization of the casein present in the study diets. Furthermore, the decline in energy absorption with greater intake of cassava may have impaired somewhat the retention of the nitrogen that was absorbed. Further research will be required to identify the anti-nutritional factor (s) present in cassava.

The increased fecal losses of carbohydrate and energy with cassava were not surprising since non - digestible fiber contributes to the total carbohydrate (and energy) content of the product, but not to the control diet. Further laboratory analyses will attempt to distinguish between fiber and non - fiber carbohydrate and energy losses in the stool.

The reduced fat excretion with cassava as compared with the control diet cannot be explained, but it is consistent with previous observations noted during studies of other staple foods such as: potatoes and noodles.

The physical properties of the cassava diet undoubtedly contributed to its delayed consumption with increasing amounts of cassava, the diet was progressively more gelatinous, (voluminous) and required greater effort by the caretakers to assure complete consumption. Whereas the control (and 25, and 50%) diet was liquid and consumed from a feeding bottle, the 75% diets had to be fed by spoon. Prolonged feeding times may result in reduced intakes in home settings where already overburdened mothers may not be able to contribte the necessary time to assure that their infants consume the entire ammount of the preparation that is offered.

4.0 Stimulation program for undernourished children:

The Stimulation Program at the IIN was initiated late in December 1983 with the goal of facilitating the recovery of motoric, linguistic, emotional and intelectual skills in children suffering from severe malnutrition. Both, the evaluation and programatic aspects of the program are adaptations of the "Programa Integral de Estimulación Temprana con Base en la Familia" (PIETBAF), developed by the Instituto Nacional de Investigación y Desarrollo en Educación (INIDE), del Ministerio de Educación, en 1983.

The stimulation program includes both a clinical and a research component.

4.1 Clinical program

All children admitted to the IIN for treatment of malnutrition eligible for the clinical component of the stimulation program. Developmental evaluation serve as the basis for individualized stimulation programs. The play therapist coordinates the stimulation activities through direct contact with the children and recommendations to the nurses, parents, and volunteers.

The PIETBAF has been operationalized to be used as an evaluation procedure with children recovering from malnutrition. The initial evaluation is scheduled as soon after admission as the child's medical condition is stable, usually within the first 10 days. Thereafter, evaluations are done on a monthly basis, with a final evaluation at discharge.

Evaluation selection scoring, and results are developed, from the results of evaluation the therapist writes a report, including a resume of the child's developmental status and individualized recommendations for stimulation activities designed to facilitate further change.

4.2 Evaluation Results

During each evaluation the therapist also observes the child's general health status and the child's cooperation, socialibility, and attention. For each area the child receives a score of Low, Medium, or High. Finally, the therapist notes whether the child has displayed a representative repertoire of behavior, which is coded as Complete or Incomplete.

From the results of the evaluation the therapist writes a report, including a resume of the child's developmental status and individualized recommendations for stimulation activities designed to facilitate further change. These recommendations are based on the PIETBAF and are practical and easy to implement.

The results of the developmental evaluations and recommendations for developmental activities are communicated to the IIN staff through weekly case conferences, Thursdays between 2:00 - 3:00, and through bulletin boards in the two primary hospital rooms for children.

4.3 Play Therapist

The Play Therapist maintains an individualized program for each nutritionally deprived child recovering at the IIN. The programs are designed to facilitate growth in each of the six developmental areas and are administered in a context of play. The Play Therapist visits each child daily and coordinates stimulation activities either in the children's hospital room or in the Play Room. For children who are in metabolic collection and in bed, she provides bed activities, including resistive exercises for their legs. When possible children in metabolic collection spend part of each day in one of the four specially adapted metabolic strollers. During stimulation children who are not in metabolic collection spend as much time out of their beds as possible. Children with similar developmental skills are programmed together for group activities, thus learning from one another in a social context.

The Play Therapist serves as a resource to the IIN staff. Although she works with each child daily, she alone is unable to provide the stimulation needed by children recovering from nutritional deprivation. Consistent, affective involvement by parents, hospital staff, and volunteers who have been trained in appropriate developmental activities, is necessary for optimal behavioral rehabilitation.

4.4 Training in Stimulation Activities

In order to provide a baseline of knowledge about child development and stimulation activities, a series of five training sessions were held with the nursing staff. To supplement these discussions, large charts were made for the wall of the nursing area depicting the age categories and representative tasks in each developmental area, based on PIETBAF. These

The mean fecal wet weight during the cassava period was greater than during the contiguous control periods. The difference from the earlier period only was statistically significant. There were no differences in fecal dry weight in any dietary interval.

Fecal fat was slightly less and fecal carbohydrate slightly more with the cassava diet than with the comparisson diets. These differences were statistically significant when compared with the second control period. These opposing effects resulted in similar fecal total energy excretion during each period. There were no differences in increments in body weight or serum albumin or in the average duration of feedings during any interval of the study.

2.2 50% of dietary energy from cassava (Table 3).

With 50% of dietary energy provided by cassava apparent nitrogen absorption declines slightly with respect to the control diets. This difference was statistically significant when compared with the second control period. Apparent nitrogen retention was significantly, less with cassava than during either control period.

Fecal wet weight was almost twice as great during the cassava period than during the paired control periods. These differences as well as those for fecal dry weight were statistically significant in relation to the prior and subsequent control diets.

Fecal carbohydrate excretion was approximately three times greater with cassava, whereas fat excretion was only half as much as with the control diets. As a result, fecal energy losses were only moderately greater with the cassava diet. All of these findings were statistically significant.

As with the "25%" cassava diet there were no differences in weight gain or serum albumin levels by dietary intervals. Approximately eight minutes were required to consume each feeding of cassava as offered to approximately five minutes for the control diets, a difference that was statistically significant for the first cassava control period.

2.3 - 75% dietary energy from cassava (Table 4).

As noted with the "50%" cassava diet, the apparent absorption and retention of nitrogen were reduced with the "75%" cassava diet compared with its respective controls The fecal wet and dry weights, fecal carbohydrate, and fecal energy were all significantly greater with the cassava diet. Fecal fat was less during the cassava period, but not significantly. There were no significant differences in increments of body weight or serum albumin. The children required a feeding period that was approximately two and a half times longer in order to consume the cassava diet than the control diet.

2.4 - Comparisson of three levels of cassava (Table 5).

The apparent absorption and retention of nitrogen decreased significantly as a greater proportion of dietary energy was provided by cassava. Likewise, fecal wet and dry weight and fecal excretion of carbohydrate and energy were greater with increasing cassava consumption. Although fecal fat excretion was consistently less with cassava than with the control diet, there was no apparent relation between the amount of cassava consumed and the efficiency of fat absorption.

charts serve as a permanent reminder of normal child development activities for both staff and visitors.

4.5 Parent Involvement

Parents are taught appropriate developmental activities for their children during visitation and prior to discharge. However, parent visitation patterns vary, with some families visiting several times a week and others practically abandoning their children. Currently there are no funds to support transportation, thus formalized parent education is beyond the scope of the present Stimulation Program.

Similarly, follow-up is an expensive process, which should be included as part of a Stimulation Program. Children are periodically reevaluated when they return to the outpatient department after discharge, but not on a regularly scheduled basis. Additional financial support is necessary to implement the follow-up phase of the program.

5.0 DETERMINATION OF THE HYDROGEN CONCENTRATION IN EXPIRED AIR.

5.1 INTRODUCTION:

Breath hydrogen tests have been used during the last twelve years for gastrointestinal diagnoses. This non-invasive procedure is useful in the diagnoses of carbohydrate malabsorption, bacterial over growth in the small intestine, and small intestinal transit time. It has also been successfully applied in the study of colonic metabolism of fiber and non-absorbable carbohydrates.

Certain colonic bacteria are capable of fermentingavailable carbohydrates with the concomitant production of hydrogen gas. Although the majority of the hydrogen is eliminated as flatus, 14 to 21% is absorbed and subsequently excreted through the lungs. The excretion of expired hydrogen provides semi-quantitative information regarding the intestinal fermentation of carbohydrates and appears to be the best index of carbohydrate malabsorption.

The first studies of breath hydrogen excretion used a closed system of continuos respiration for the collection of expired air, but presently a hydrogen sampling system at fixed intervals after an oral dose of carbohydrate has been developed. The procedure is non-invasive and is suitable for infants and young children.

During the present studies the breath hydrogen test was performed on children consuming cassava at three different levels (25, 50 and 75%) of total dietary energy in order to determine whether excess carbohydrate entered the colon. Additionally, results of breath hydrogen excretion were compared with data for fecal energy excretion as determined by bomb calorimeter.

5.2 PATIENTS, PROCEDURES AND METHODS:

Eight partially recovered malnourished children participated in this study. Determinations of hydrogen concentration of expired air were done during each period of yuca, 25%, 50% and 75% and in the initial CASEC control period. Control tests were also done with lactulose (a non-absorbable carbohydrate) in each child before starting the study to assure that the colonic flora were capable of producing hydrogen. For the control experiment with lactulose, 11 children were studied (3 of them did not participate in the yuca study). They received a dose either 3.33g or 6.7g of lactulose in a 10% solution in water, after obtaining a basal sample of expired hydrogen. This basal sample was obtained after 8 to 12 hours of fasting. Samples were obtained at 30 minute intervals for 180 to 240 minutes.

For the cassava study basal samples of fasting breath H2 concentration were collected. Samples of expired air were the collected at 30 minute intervals up to 240 minutes after the first feeding and at 60 minute intervals for an additional 240 minutes after the second feeding.

The expired air was collected in a pediatric anesthetic mask that was connected through a polyethylene tube to a 15 cc syringe. At the end of each expiration, 1 to 3cc of air were aspirated into the syringe until a total volume of 40cc was obtained.

The hydrogen concentration of the air samples were analysed during same day using a Quintron model S gas chromatograph, which uses a thermal conductivity detection system. Argon was used as the carrier gas. The results were compared with a commercial standard of 55ppm of hydrogen in air.

Five parameters were used for interpretation of the breath hydrogen data:

a) Basal value.- The measurement of the hydrogen concentration in breath immediately before feeding.

b) Peak increment.- The difference between the highest post-prandial value and the basal value.

c) Maximal differences.- The differences between the highest and the lowest pre or post-prandial values.

d) The time required to reach the maximal peak of hydrogen excretion.

e) Excess concentration of expired hydrogen, i e, the integration under a discontinuous curve of the excess hydrogen excreted during each interval, which has been calculated by the following formula of the sum of the trapezoids:

$$\frac{(To - To)}{2} + (Ti - To) + \frac{(Ti - To)}{2} + (Tii - To) + \cdots\cdots$$

$$+ \frac{(Tn - i - To)}{2} (Tn - To)$$

Where To is the hydrogen concentration in ppm in time zero; Ti is the hydrogen concentration in ppm at the end of the first interval. Tii is the hydrogen concentration in the last interval.

5.3 RESULTS:

Lactulose Tests: The lactulose test resulted in a marked increase (> 20 ppm) in the expired hydrogen concentration in all the patients, except in the case of patient number 871 in whom there was no increase with either of the two levels of lactulose (Table 1). The average time required to reach the maximal peak in hydrogen concentration was 120 minutes, while the excess in the hydrogen concentration in ppm was greater than 2000 ppm for all patients except for patient 871 in whom there was no significant increase and patient 839 whose basal level was greater than 40 ppm. Patient 825 had a significant increase in the total hydrogen excretion despite a basal level of 53 ppm.

The concentration of expired hydrogen following lactulose doses of 3.33g and 6.7g are shown for three patients in figure 1. Patient 806 shows the best hydrogen excretion curve; for dose 6.7g., the excess in hydrogen concentration in ppm increased proportionally.

In patient 871 the hydrogen excess was negative with 3.3g. of lactulose and did not increase importtantly increasing the dose to 6.7g. in this same patient we may see variations in hydrogen concentration in ppm for each time interval (Figure 2).

5.4 Basal H2 Excretion with Cassava:

When analyzing the effect of the diet previously ingested on the basal expired hydrogen we observe that as the proportion of calories derive from cassava increased, there was an increase in the hydrogen concentration of the basal expired air (Table II (Fig.3). It can also be observed in the same table that the fecal excretion of carbohydrate increased progressively with the increment of yuca in the diet.

5.5 Excess Hydrogen Excretion with Cassava:

The excess breath hydrogen concentration was calculated for an eight hour - period following ingestion of cassava. (Table

The first patient only had samples taken for four hours post prandially. We may clearly see that the hydrogen concentration is greater in the afternoon (B interval) after receiving the second feeding in that morning (A interval) for those patients with the full eight hours of observation. This is true for all four diet periods.

In the patients who didn't have hydrogen samples in the B interval, the hydrogen excess was zero. For the majority of patients the hydrogen excess for the Yuca 75% was zero because the basal value was greater than any other value measured.

DISCUSSION

The control test with lactulose perform in all 11 children, showed that only one child (9%) was not able to produce hydrogen in significant amounts. This child probably did not have microbial flora in the colon capable of fermenting lactulose. But, by the curve obtained with a dose of 3.3g of lactulose (Figure 2) in which the maximal peak was at 30 min., it seems a typical curve of microbial contamination of the small intestine.

The effect of the diet previously ingested in the basal expired hydrogen suggests that the non - absorbed carbohydrate (fiber) content in Yuca (around 8%) influenced the hydrogen excretion.

Other investigators have demonstrated that certain types of dietary fiber or complex carbohydrates affect the concentration of basal expired hydrogen. These studies were performed with a legume - based diet, in which a small increase in the concentration of expired hydrogen with a maximal peak observed 5 - 8 hours after the first intake of feeding was shown.

In Yuca, we have observed something similar although we have not been able to charaterize specifically the type of fiber in Yuca, it seems to affect the hydrogen excretion, delaying it and so affecting the basal hydrogen excretion the following day.

In the control period of casein, we also observed a tendency of the hydrogen concentration to increase in the afternoon (Figure 2). This may be due to the fact that this control diet contained not only sucrose, which is a highly digestible carbohydrate, but also dextrimaltose and corn starch. To be able to clearly differentiate a diet with fiber or complex carbohydrates from a control one a diet of casein - sucrose will have to be prepared.

TABLE 1

CLINICAL CHARACTERISTICS OF EIGHT CHILDREN AT THE BEGINNING OF THE FIRST STUDY OF CASSAVA

IIN N°	Hospital Day	Chronologic Age (m)	Weight (g)	Weight Age (m)	Height (cm)	Height Age (m)	Weight by Height Percentil	Serum Alb g/d
827	57	20,0	7 600	5.6	71.4	8.25	5	3.62
825	63	26 4	9.600	10.25	78.2	13.75	15	3.79
842	59	21.0	6 980	4.4	70.0	7.25	<3	3.85
849	57	35 9	6.780	4 1	74.7	10.75	< 3	3.59
848	86	20.1	10.380	12.75	79.1	14.75	35	3.83
868	36	28.5	8 830	8 0	81.0	16.5	< 3	3.50
872	85	20.5	8 600	7.5	72.8	9.25	20	4.24
891	22	37.8	9.660	10.25	79.7	15.25	5	4.17

TABLE 2

PROTEIN QUALITY AND DIGESTIBILITY OF DIET CONTAINING 25% OF ENERGY FROM CASSAVA COMPARED WITH CONTROL DIET (n = 8)

			CONTROL-PRE	CASSAVA"25"	CONTROL-PRE
NITROGEN					
Absorption	(% intake)	$\bar{X}$	83.1	83.4	82.1
		SD	± 3.7	± 6.0	± 6.0
Retention	(% intake)	$\bar{X}$	34.5	32.9[c]	44.6
		SD	± 6.3	± 8.0	±10.6
FECAL WEIGHT					
Wet	(g/d)	$\bar{X}$	84.7	120.9[a]	100.6
		SD	± 27.7	± 35.6	± 13.8
Dry	(g/d)	$\bar{X}$	16.8	16.4	18.5
		SD	± 3.9	± 3.3	± 2.9
FECAL FAT	(% intake)	$\bar{X}$	9.7	9.2[c]	12.2
		SD	± 5.2	± 4.5	± 4.7
FECAL CHO	(% intake)	$\bar{X}$	2.1	2.8[d]	1.6
		SD	± 1.0	± 0.5	± 0.9
FECAL ENERGY	(% intake)	$\bar{X}$	5.3	5.9	5.6
		SD	± 1.4	± 1.3	± 0.8
BODY WEIGHT	(g/kg/d)	$\bar{X}$	4.3	3.8	5.0
		SD	± 2.1	± 2.0	± 2.0
SERUM ALBUMIN	(g/dl/prd)	$\bar{X}$	0.17	0.07	0.19
		SD	0.28	± 0.25	± 0.27
DURATION FEEDING	(min)	$\bar{X}$	5.0	6.0	6.4
		SD	± 2.0	± 5.6	± 5.4

Statistical significance of differences (paired "t" test)

Cassava vs Control -pre: a = p < 0.05
Cassava vs Control -pre: b = p < 0.01
Cassava vs Control - post: c = p < 0.0
Cassava vs Control - post: d = p < 0.0

TABLE 3

PROTEIN QUALITY AND DIGESTIBILITY OF DIET CONTAINING 50% OF ENERGY FROM CASSAVA COMPARED WITH CONTROL DIET (n = 8)

			CONTROL-PRE	CASSAVA "50"	CONTROL-POST
NITROGEN					
Absorption	(% intake)	$\bar{X}$	81.3	78.6[c]	81.5
		SD	± 6.8	± 5.1	± 3.7
Retention	(% intake)	$\bar{X}$	39.1	31.0[a,c]	39.3
		SD	±13.1	± 7.8	±10.4
FECAL WEIGHT					
Wet	(g/d)	$\bar{X}$	100.6	195.7[b,d]	117.9
		SD	± 52.7	± 44.1	± 40.8
Dry	(g/d)	$\bar{X}$	18.8	23.8[a,d]	20.6
		SD	± 4.4	± 3.8	± 3.1
FECAL FAT	(% intake)	$\bar{X}$	17.1	8.0[b,c]	14.0
		SD	± 8.0	± 4.2	± 7.2
FECAL CHO	(% intake)	$\bar{X}$	1.5	6.0[b,d]	2.3
		SD	± 0.8	± 1.1	± 1.0
FECAL ENERGY	(% intake)	$\bar{X}$	6.7	9.5[a,d]	6.3
		SD	± 1.8	± 3.2	± 1.4
BODY WEIGHT	(g/kg/d)	$\bar{X}$	3.8	3.0	4.6
		SD	± 3.0	± 1.9	± 3.6
SERUM ALBUMIN	(g/dl/per)	$\bar{X}$	0.09	0.16	0.04
		SD	± 0.28	± 0.26	± 0.35
DURATION FEEDING	(Min)	$\bar{X}$	4.8	8.0	5.2
		SD	± 0.7	± 4.8	± 2.3

Statistical significance of differences:

Cassava vs Control pre : a $p < 0.025$
Cassava vs Control pre : b $p < 0.001$
Cassava vs Control post : c $p < 0.025$
Cassava vs Control post : d $p < 0.001$

TABLE 4

PROTEIN QUALITY AND DIGESTIBILITY OF DIET CONTAINING 75% OF ENERGY FROM CASSAVA COMPARED WITH CONTROL DIET (n = 8)

			CONTROL - PRE	CASSAVA "75"	CONTROL - POST
NITROGEN					
Absorption	(% intake)	$\bar{X}$	82.7	75.6[b]	80.8
		SD	± 4.1	± 5.7	±16.0
Retention	(% intake)	$\bar{X}$	38.4	28.6[a,c]	37.3
		SD	± 9.3	± 8.5	± 11.0
FECAL WEIGHT					
Wet	(g/d)	$\bar{X}$	94.5	240.0[b,d]	132.3
		SD	± 23.0	48.6	± 61.1
Dry	(g/d)	$\bar{X}$	17.3	31.4[b]	20.8
FECAL FAT	(% intake)	$\bar{X}$	13.1	10.6	14.5
		SD	± 5.0	± 4.8	± 4.0
FECAL CHO	(% intake)	$\bar{X}$	1.8	8.6[b,d]	1.7
		SD	± 0.8	± 0.8	± 0.8
FECAL ENERGY	(% intake)	$\bar{X}$	5.6	10.0[b,c]	6.3
		SD	± 1.4	± 4.4	± 2.6
BODY WEIGHT	(% intake)	$\bar{X}$	4.5	3.6	3.7
		SD	± 2.2	± 2.2	± 2.1
SERUM ALBUMIN	(g/dl/prd)	$\bar{X}$	-0.11	0.30	0.06
		SD	± 0.41	± 0.45	± 0.31
DURATION FEEDING	(min)	$\bar{X}$	6.0	16.5[a,c]	6.0
		SD	± 5.4	± 12.3	± 4.3

Statistical significance of Differences (paired "t" test)

Cassava vs Control pre : a = p 0.025 Cassava vs Control post : c = p < 0.0
Cassava vs Control pre : b = p 0.005 Cassava vs Control post : d = p 0.0

TABLE 5

DIGESTIBILITY AND TOLERANCE PARAMETERS ON EIGHT CHILDREN RECEIVING THREE ENERGY INTAKE LEVELS FROM CASSAVA

		CASSAVA 25	CASSAVA 50	CASSAVA 75
NITROGEN:				
Absorption	(%)	83*b	79	76
Retention	(%)	33	31	29
Biological Value	(%)	40	39	38
FECES:				
Wet Weight	(g/d)	121*d	196	240***c
Dry Weight	(g/d)	16.4*d	23.8**a	31.4***d
FAT:				
% Intake		9.2*a	8.0	10.6
CARBOHYDRATES:				
% Intake		2.8*d	6.0**d	8.6***d
ENERGY:				
% Intake		5.9*d	9.5**b	10.0***d
BODY WEIGHT:				
	(g/day)	35	28	34
	(g/kg/day)	3.8	3.0	3.6
SERUM ALBUMIN:				
Initial	g/dl	3.81	3.56	3.81
Final	g/dl	3.88	3.72	3.51
Difference		0.07	0.16	-0.30
DIET TOLERANCE:				
Min/Feeding		6.0	8.0**b	16.5***a

* Cassava 25% vs. Cassava 50%
** Cassava 50% vs. Cassava 75%
*** Cassava 25% vs. Cassava 75%

a) p < 0.05
b) p < 0.025
c) p < 0.01
d) p < 0.001

T A B L A I

EXSESO DE LA CONCENTRACION DE H2 ESPIRADO EN PPM, INCREMENTO DEL PICO Y TIEMPO REQUERIDO PARA LLEGAR A ESE PICO LUEGO DE UNA DOSIS DE LACTULOSA

PT. N°	DOSIS (gr)	EXSESO H2 (ppm)	INCREMENTO (Δ) (ppm)	TIEMPO DEL Δ (min)
800	6.7	7095	53.9	105'
800	3.33	4295	78.8	120'
806	6.7	4700	39.1	90'
806	3.33	5295	31.4	90'
871	6.7	1769	19.6	120'
871a	3.33	195	8.9	30'
825b	6.7	6008	88.0	120'
827	6.7	6111	58.4	120'
839b	3.33	384	28.3	180'
842	3.33	12456	121.1	150'
848	3.33	5587	62.7	120'
868	3.33	3987	79.3	90'
872	3.33	4298	54.8	90'
891	3.33	9563	68.8	210'

a= Basal = 20 ppm

b= Basal > 40 ppm

TABLA II

EFECTO DE LA DIETA PREVIAMENTE INGERIDA EN EL H_2 ESPIRADO BASAL Y EN LA EXCRECION FECAL DE CARBOHIDRATOS EN 8 NIÑOS CONSUMIENDO DIETAS DE CASEINA-SUCROSA O DIFERENTES NIVELES DE YUCA

	PT.N°	PERIODO DE CASEC	PERIODO DE YUCA 25%	PERIODO DE YUCA 50%	PERIODO DE YUCA 75%
H_2 Esp. Basal (ppm)	827	10.8 ± 3.6	27.7 ± 0.1	11.7 ± 0.1	14.6 ± 1.9
	825	21.6 ± 7.0	11.5 ± 1.7	13.0 ± 1.8	24.8 ± 8.6
	842	8.5 ± 1.4	8.8 ± 2.6	18.8 ± 5.6	31.9 ± 8.2
	849	10.0 ± 3.4	7.6	31.6 ± 28.7	18.4 ± 4.2
	848	10.8 ± 2.1	-	11.1 ± 2.5	15.6 ± 8.2
	868	10.3 ± 1.1	8.1 ± 1.6	25.4 ± 3.8	49.2 ± 22.9
	872	8.7 ± 2.1	7.2 ± 0.5	9.3 ± 1.1	10.1 ± 3.6
	891	12.3 ± 3.0	8.0 ± 0.7	9.2 ± 1.5	8.4 ± 2.7
	Mean ± S.D.	11.6 ± 4.2	11.3 ± 7.4	16.3 ± 8.3	21.6 ± 13.5
	C.V.	36%	65%	51%	62%
CHO Fecal Exc. (% Ingesta)	827	2.60	3.10	7.25	8.60
	825	1.75	5.05	5.70	9.60
	842	2.69	3.33	6.75	9.02
	849	2.69	2.69	8.56	9.23
	848	0.54	1.68	4.96	7.29
	868	1.53	2.73	4.04	7.43
	872	1.26	2.83	6.60	9.20
	891	2.52	2.86	6.97	8.28
	Mean ± S.D.	1.95 ± 0.80	2.78 ± 0.49	6.35 ± 1.41	8.58 ± 0.86

T A B L A III

EXSESO DE LA CONCENTRACION DE HIDROGENO TOTAL EN ppm EN NIÑOS CONSUMIENDO DIETA DE CASEINA-SUCROSA-ALMIDON O DIFERENTES NIVELES DE YUCA

PAT Nº	CASEC		YUCA 25%		YUCA 50%		YUCA 75%	
	INT.A	INT.B	INT.A	INT.B	INT.A	INT.B	INT.A	INT.B
827	254	0b	45	0b	64	67	0	0b
825	25	0	5.6	649	0	0b	0	0b
842	596	0b	156	0b	0.2	538	0	0
848	549	825	-	-	173	906	0	0
868	995	709	595	729	69	0	0	0
849	3813=	12512c	283	1538	0.7	1189c	0	28
872	24	918	421	1224	108	1959	1236	3108c
891	78	598	291	1071	0	2250c	11	1851
Promedio n	739 8	2560 6	225 7	1002 5	52 8	987 7	156 8	851 6

a = Intervalo A ≤ 240; Intervalo B ≥ 240'

b = Muestras Tomadas solo hasta los 180' (Int.A)

c = Incremento (Δ) > 20ppm

FIGURA N°1

CAMBIOS EN LA CONCENTRACION DE H_2 ESPIRADO SOBRE EL NIVEL BASAL (EXCESO DE LA CONC. DE H_2 ESP.) A 0.5h INTERVALOS CON DOSIS DE 3.33 Y 6.7g. DE LACTULOSA, EN 3 NIÑOS RECUPERADOS,

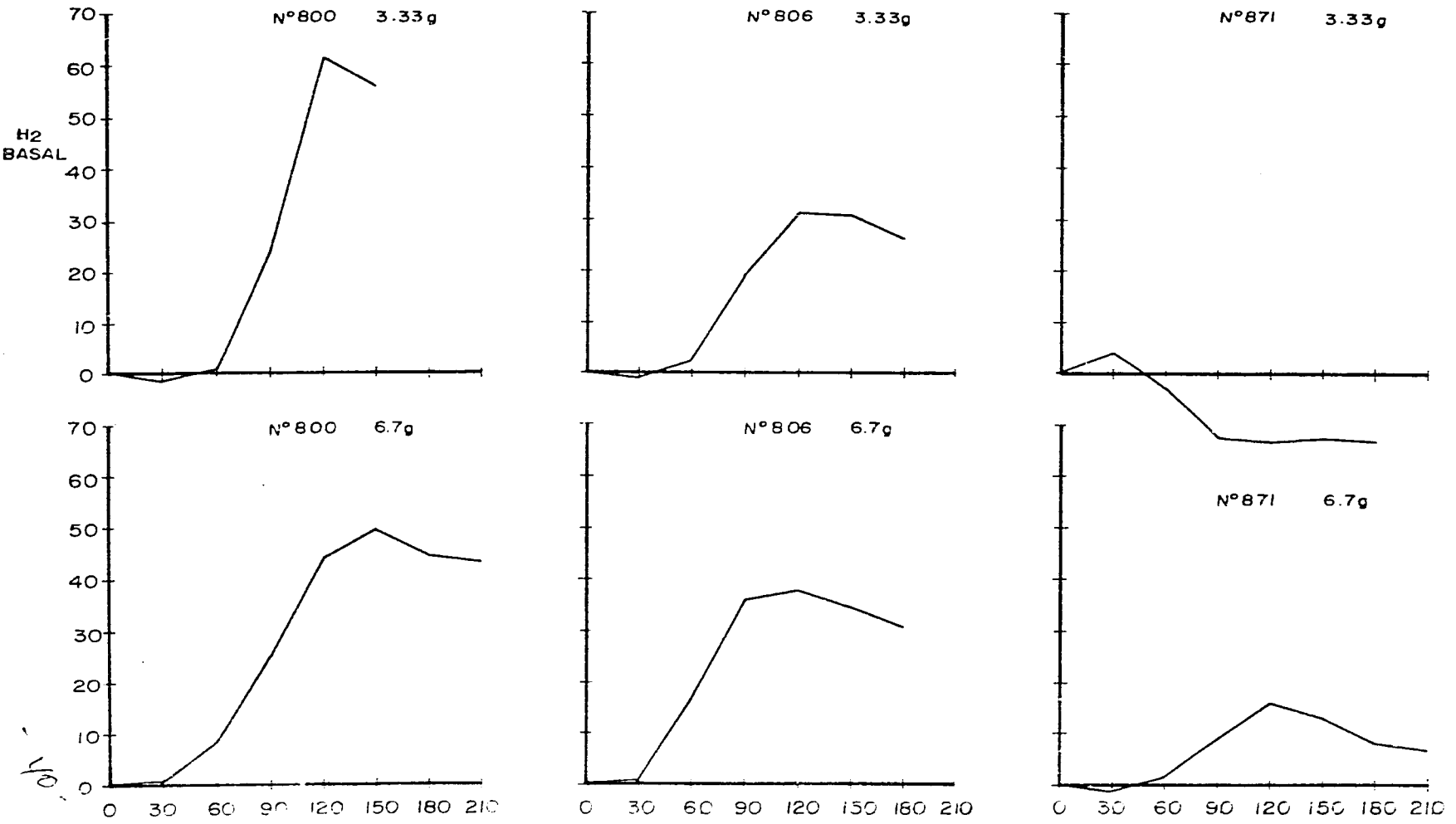
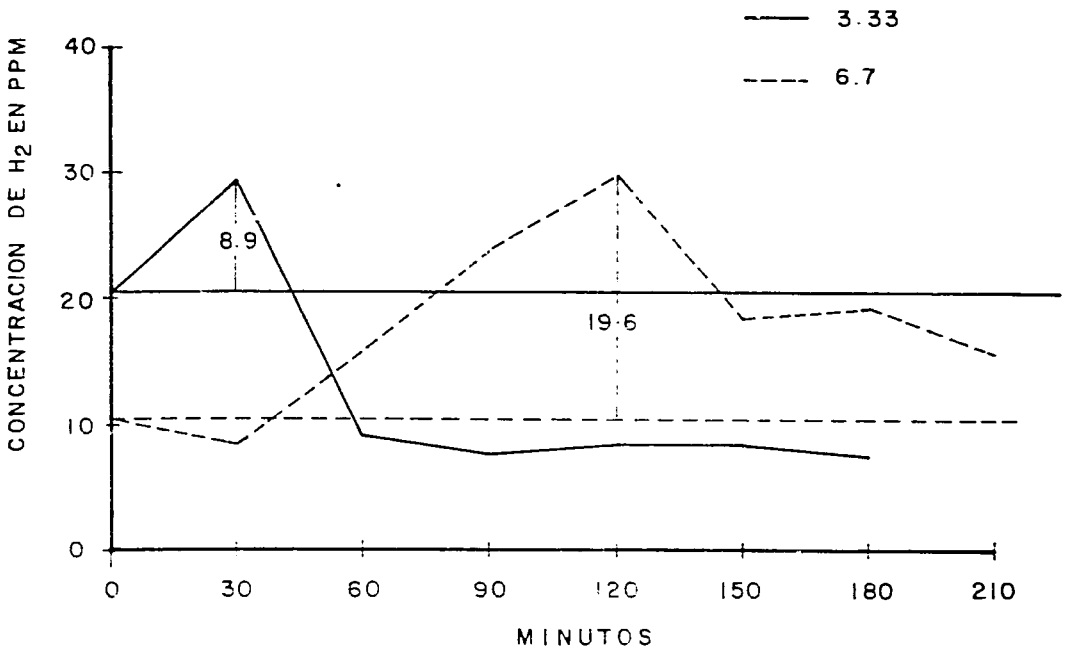
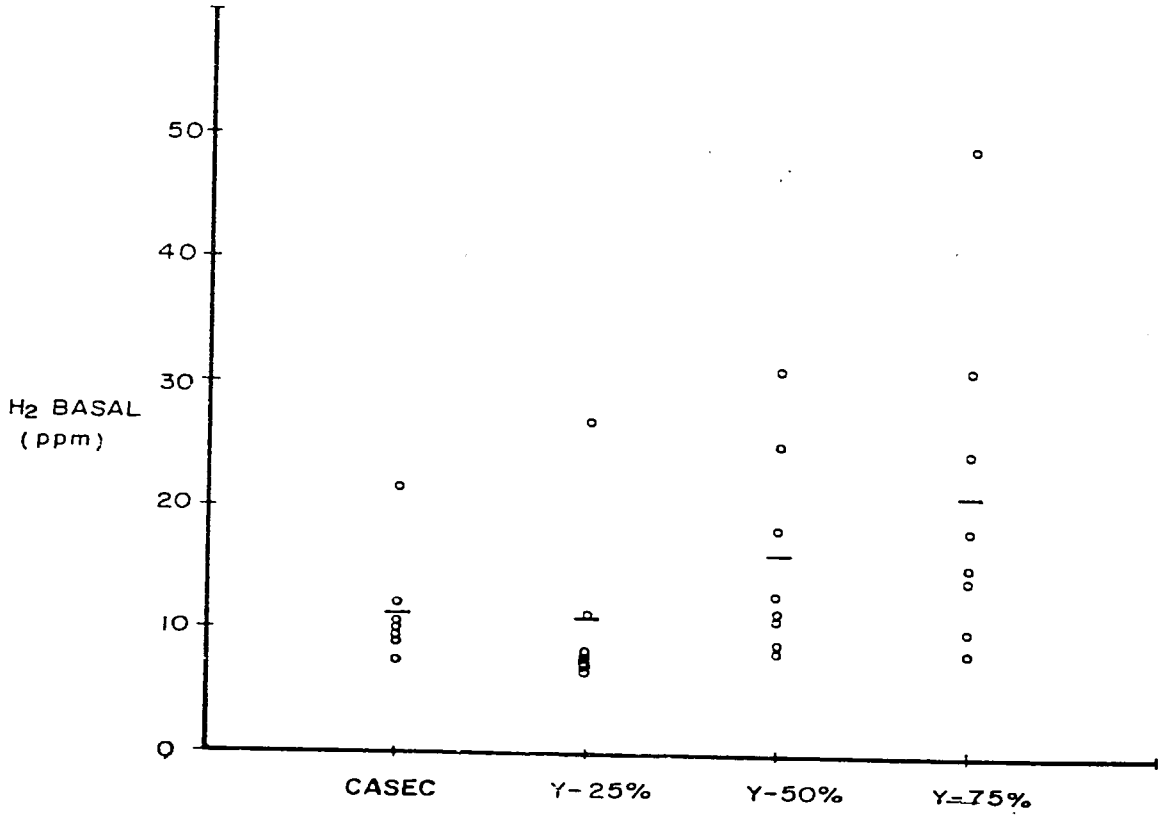


FIGURA N°2

CAMBIOS EN LA CONCENTRACION DE H_2 EN PPM, A INTERVALOS DE 30min. SOBRE 3 1/2 HORAS, CON DOSIS DE 6.7 Y 3.33gr. DE LACTULOSA, EN EL PACIENTE No 871.



EFECTO DE LA DIETA PREVIAMENTE INGERIDA EN EL H_2 ESPIRADO BASAL EN 8 NIÑOS RECUPERADOS.



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Linda Lou Kelley
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3. n-04

INSTITUTO DE INVESTIGACION NUTRICIONAL
(IIN - NUTRITIONAL RESEARCH INSTITUTE)
LA MOLINA (LIMA), PERU

CASSAVA: CONSUMPTION AND DIGESTIBILITY BY SMALL CHILDREN

PROJECT N° 936 - 5542

Second Study: "Effects of variety and processing method on digestibility"

Fourth Report to AID, covering period January 1st. through June 30, 1985

George G. Graham, M.D.
Principal Investigator

Oscar Enrique Morales, M.D.
Co-Principal Investigator

Rec'd in SCI: DEC 4 1985

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Fourth Report to AID, covering period January 1st. through June, 1985.

During this period we studied the digestibility of 3 varieties of cassava and the effect of processing method on the digestibility of the same two varieties of cassava, selected with the cooperation of the International Institute for Tropical Agriculture (IITA), from Nigeria; these varieties were processed at the same institute in two ways:

1.- "Farinha de mandioca" as in Brazil and
2.- "Gari" partially fermented as in Nigeria.

The amount to be fed to the children is 50% of the calories from the cassava.

1.0 Methods: The methods were presented in detail in the original protocol.

1.1 Subjects.- Up to date, we have completed the study in six children of the eight children programed for the cassava 60142 variety, and in three children for the cassava 4 - 2 - 1425 variety.

Clinical characteristics of these children at the beginning of the study are shown in Table 1 and 2.

Most of the children participating in the study filled the criteria for inclusion described in the protocol. Patients N° 907, 931 had less than 3rd. percentile wt/ht.

1.2 Sequence and duration.- Children were assigned at random to one of the two varieties (60142 or 4 - 2 - 1425) and received the same variety, in both ways Gari and Farinha, the sequence of feeding of Gari and Farinha was also assigned at random.

The initial casein control diet period and each of the cassava periods lasted nine days; the intervening and final casein periods lasted six days each, this makes a total of 39 days for each study.

1.3 Diets.- In a previous study with 3 levels of calorie intake provided by cassava (25, 50, and 75%), we found that the tolerance and digestibility of the diets with 75% of energy intake from cassava were impaired by the bulk of the diet.

Since there was no statistical difference in diet tolerance between the 25 and 50% of energy intake from cassava in the previous study, and the tolerance and digestibility in the 75% of energy intake from the cassava was impaired by the bulk of the diet, we decided to use the 50% level of energy intake from cassava for this second study.

Tables 3, 4, 5 and 6 show the ingredients, nutrients and energy distribution of the cassava diets : in the two varieties (60142 and 4 - (2) 1425) and in the two processing ways (Gari and Farinha), and table 7 shows the same for control diet.

For all diets we added calcium caseinete, vegetable oil, corn syrup solids and sucrose to achieve 8% protein calories, 20% fat calories and 72% carbohydrate calories, a vitamin mineral mixture was added to meet the FNB Recommended Dietary Allowances.

In the study diets, protein from cassava ranged only from 5.8% to 9.6% of the total intake, and the remain protein from casein, ranged 90.4 to 94.2%.

2.0 Results: Selected criteria of digestibility on 6 children receiving cassava Gari - 60142 and control diet are presented in Table 8.

Feces wet and dry weight, fecal carbohydrate as well as fecal energy were greater during Gari diet than during the preceding and following control diets, the differences were significant ($p < 0.05$). There was no difference in fecal fat between the Gari and control diets.

Nitrogen absorption and retention were lesser in Gari than in the preceding and following control diets, but the difference was significant only in Nitrogen retention between the Gari and the following control diet.

Gain in body weight was less during the Gari period than in the control diet periods, but the differences were not significant. Serum Albumin levels diminished during the Gari dietary period, statistical analysis will be done at the end of the study.

2.2 Digestibility parameters on 6 children receiving cassava: Farinha - 60142 and control diets (Table 9).

As in the case of Gari, the feces wet and dry weight, fecal carbohydrate and fecal energy values were greater during Farinha diet than in the preceding and following control diets, the differences were significant. ($p<0.05$).

Nitrogen absorption and retention were less in Farinha than in the preceding and following control diets, the differences were significant ($p < 0.05$).

There were no significant differences in fecal fat values, gain in body weight, and serum albumin values during Farinha diet and control diet periods.

2.3 Digestibility parameters on 6 children receiving Gari and Farinha, 60142 variety: (Table 10).

Values for feces wet and dry weight, fecal energy, fecal carbohydrate and fecal fat were less in Farinha than in Gari (60142) diet periods, but the differences were significant only in energy as a % of intake.

There were no significant differences in nitrogen absorption and retention, gain in body weight and serum albumin values during Farinha diet compared with Gari diet period.

2.4 Digestibility parameters on 3 children receiving cassava: (4 - 2 1425) Gari and control diets. (Table 11).

Values for feces wet and dry weight, fecal energy and fecal carbohydrate were greater during the Gari diet period than during the preceding and following control diet periods, differences were significant in most of them.

Nitrogen absorptian and retention for the Gari were lesser than the preceding and the following control diets; the differences were significant. ($p<0.05$).

There were no significant differences in nitrogen absorption and retention, gain weight, and serum albumin values during Gari (4 - 2 - 1425) diet and the preceding and following control diet periods.

2.5 Digestibility parameters on 3 children receiving cassava : Farinha (4 - 2 - 1425) and control diets : (Table 12).

Values for fecal wet and dry weight, energy and carbohydrate for the Farinha diet period were greater than during the preceding and following control diet period. Differences were significant in all but one of the parameters.

Nitrogen absorption and retention for Farinha diet period were lesser than the preceding and following control diet periods; differences were significant in all but in retention of the preceding control diet.

There were no significant differences in fecal fat, gain in body weight, and serum albumin values during Farinha (4 - 2 - 1425) diet compared with the preceding and following control diet periods.

2.6 Digestibility parameters on 3 children receiving cassava (4 - 2 - 1425): Gari vs Farinha (Table 13). Values for feces wet and dry weight and carbohydrates were greater for Farinha than for Gari (4 - 2 - 1425). Differences were significant only in g/day carbohydrate. Fecal energy in Farinha was lesser than in Gari, the difference was not significant.

There were no differences in most of the digestibility parameters between Farinha and Gari (4 - 2 - 1425), diets, this might have been because of the reduced number of cases.

2.7 Chemical composition of Peruvian and Nigerian Cassava are shown in Table 14 :

Nitrogen and protein content of Peruvian cassava is similar to the Nigerian 4 - 2 - 1425 variety and both are higher than the Nigerian 60142 variety. Moisture in lyophilized Peruvian cassava is less than both Nigerian cassava varieties; but cianhydric acid content is higher in the Peruvian (lyophilized) than in the processed Nigerian cassava.

2.8 Digestibility parameters on Peruvian Lyophilized and Nigerian cassava varieties are shown in Table 15 : * (each one of the cassava diets providing 50 % of the total energy).

With the exception of percentage of carbohydrate intake for lyophilized with Gari 60142, and of the serum albumin far the lyophilized with Gari - 60142 and with Farinha 4 - 2 - 1425 cassava, in the other digestibility parameters there were no significant differences between Peruvian (jungle) and each one of the Nigerian cassava varieties in colums a, b, c, and d.

3.0 Discussion: These studies indicate that both the Nigerian fermentation technique called Gari as well as the Brazilian one called Farinha, are comparable in digestibility parameters with the Peruvian lyophilized cassava, for either varieties 60142 or 4 - 2 - 1425.

It seems that the latest variety is a little better than the former, but the differences are not significant, we need more patients in this study to obtain a better result.

Besides that most of the protein of the diet comes from the casein, the apparent nitrogen absorption and retention in the Nigerian cassava was lesser than in the control diets, the same was obtained in the previous study with lyophilized Peruvian cassava. It would be possible that some factor in cassava is interferring with the nitrogen absorption and its availability.

The greater body weight gain during Nigerian 4 - 2 - 1425 cassava diet is not significantly different from the 60142 and Peruvian varieties, this could be because of the short periods of time.

4.0 The low cianhydric acid content of the Nigerian cassava indicates that the fermentation technique is very effective in removing the linamarine of the root. We can not say the same for the lyophilized technique used for Peruvian cassava.

It seems that the procedure for lyophilization of the cassava retains the cianhydric acid (CNH) because the water containing this acid is evaporated but not drained. This explains the high content in the two varieties: yellow and white cassava we analysed (39.2 and 66.6 ppm, respectively).

The amount of CNH the children received in diets were as follows:

	mg/kg of body weight
Peruvian lyophilized white	0.86
Peruvian " yellow	0.50
Nigerian 60142 Gari	0.037
Nigerian 60142 Farinha	0.049
Nigerian 4 - 2 - 1425 Gari	0.043
Nigerian 4 - 2 - 1425 Farinha	0.027

5.0 The Psichological Stimulation Program is going well. All the children participating in the study were stimulated as well as all the children admitted to the IIN. Mrs. Clara Ferrari and Mrs. M. Black are reporting about this project, including the parents program.

TABLE 1

CLINICAL CHARACTERISTICS OF SIX MALE CHILDREN PARTICIPATING IN THE CASSAVA STUDY: GARI vs FARINHA 60142

IIN N°	Hosp. Day	Chronol. Age (mos)	Weight (kg)	Weight Age (mos)	Height (cm)	Height Age (mos)	Weight/Height			Initial Serum	
							% *	Percentile	Z-Score	Protein g/dl	Albumin g/dl
904	61	12.3	7.630	5.6	69.2	6.75	93.3	20	-0.9	5.81	3.34
907	53	10.3	5.830	2.7	65.8	4.9	80.5	≤ 3	-2.0	6.95	4.33
908	91	10.0	7.230	4.8	66.5	5.3	97.3	30	-0.46	5.99	4.04
913	97	14.6	6.930	4.3	65.8	4.9	95.7	30	-0.41	7.22	4.22
931	22	12.6	6.140	3.2	67.1	5.6	80.8	< 3	-2.12	8.24	3.77
932	49	18.5	9.015	8.5	74.4	10.5	92.9	20	-0.73	6.41	3.89

* % of the NCHS reference.

TABLE 2

CLINICAL CHARACTERISTICS OF THREE MALE CHILDREN PARTICIPATING IN THE CASSAVA STUDY: GARI vs FARINHA 4 (2) 1425

iIN N°	Hosp. Day	Cronolog. Age (mos)	Weight (kg)	Weight Age (mos)	Height (cm)	Height Age (mos)	Weight/Height			Serum	
							%	Percentile	Z-Score	Protein g/dl	Albumin g/dl
922	100	13.0	9.190	8.75	73.4	9.75	97.45	40	-0.15	6.07	3.98
938	45	9.3	5.600	2.5	64.1	4.2	82.10	3	-1.7	6.37	3.85
924	47	17.2	8.810	8.0	78.0	13.75	82.87	3	-1.98	7.90	3.07

TABLE 3

INGREDIENTS, NUTRIENTS AND ENERGY DISTRIBUTION OF THE CASSAVA DIETS
GARI 60 - 142

	Amount (g)	Energy Kcal	Protein (g)	Fat (g)	CHO (g)	Na mEq	K mEq
GARI	16.86	60.00	0.152	0.03	14.79	0.10	2.15
CASEC	2.61	9.49	2.25	0.05	-	0.05	0.006
VEGETABLE OIL (ml)	2.93	23.20	-	2.58	-	-	-
SUGAR	3.42	13.68	-	-	3.42	-	0.008
CORN SYRUP SOLIDS	3.51	13.62	-	-	3.40	0.21	0.015
MINERAL MIX	0.7815	-	-	-	-	0.00	-
KCl 1Mol.	0.83	-	-	-	-	-	0.83
TOTAL ·		120.0	2.40	2.66	21.61	2.36	3.00
ENERGY DISTRIBUTION (%)	-	-	8	20	72	-	-

TABLE 4

INGREDIENTS, NUTRIENTS AND ENERGY DISTRIBUTION OF THE CASSAVA DIETS:

FARINHA (60 - 142)

	Amount (g)	Energy Kcal	Protein (g)	Fat (g)	CHO (g)	Na mEq	K mEq
FARINHA	17.21	60.0	0.14	0.03	14.8	0.14	1.69
CASEC	2.62	9.51	2.26	0.05	-	0.03	0.006
VEGETABLE OIL	9.94	23.28	-	2.59	-	-	-
SUGAR	3.40	13.60	-	-	3.4	-	0.008
CORN SYRUP SOLID	3.51	13.62	-	-	3.4	0.21	0.015
MINERAL MIX	0.7815	-	-	-	-	2.00	-
KCl 1 Mol	1.28	-	-	-	-	-	1.28
TOTAL:		120.01	2.40	2.67	21.6	2.4	2.99
ENERGY DISTRIBUTION (%)			8	20	72	-	-

TABLE 5

INGREDIENTS, NUTRIENTS AND ENERGY DISTRIBUTION OF THE CASSAVA DIETS:

GARI 4 (2) 1425

	Amount (g)	Energy Kcal	Protein (g)	Fat (g)	CHO	Na mEq	K mEq
GARI	17.10	60.0	0.23	0.05	14.66	0.11	2.67
CASEC	2.52	9.14	2.17	0.05	-	0.05	0.006
VEGETABLE OIL	2.91	23.05	-	2.56	-	-	-
SUGAR	3.48	13.92	-	-	3.48	-	0.01
CORN SYRUP SOLIDS	3.58	13.89	-	-	3.47	0.21	0.015
MINERAL MIX	0.6369	-	-	-	-	1.63	-
KCl 1 Mol.	0.30	-	-	-	-	-	3.30
TOTAL		120.0	2.40	2.66	21.60	2.00	3.00
ENERGY DISTRIBUTION (%)	-	-	8	20	72	-	-

TABLE 6

INGREDIENTS, NUTRIENTS AND ENERGY DISTRIBUTION OF THE CASSAVA DIETS:
FARINHA (4)(2) 1425

	Amount (g)	Energy Kcal	Protein (g)	Fat (g)	CHO (g)	Na mEq	K mEq
FARINHA	17.86	60.0	0.23	0.04	14.68	0.16	2.56
CASEC	2.62	9.14	2.17	0.05	-	0.05	0.006
VEGETABLE OIL	2.92	23.13	-	2.57	-	-	-
SUGAR	3.47	13.86	-	-	3.47	-	0.009
CORN SYRUP SOLIDS	3.57	13.85	-	-	3.46	0.21	0.02
MINERAL MIX	0.6158	-	-	-	-	1.58	-
KCl 1Mol.	0.4	-	-	-	-	-	0.40
TOTAL:	-	120.0	2.40	2.66	21.61	2.00	3.00
ENERGY DISTRIBUTION (%)	-	-	8	20	72	-	-

TABLE 7

INGREDIENTS, NUTRIENTS AND ENERGY DISTRIBUTION OF THE CONTROL DIET

	Amount (g)	Energy Kcal	Protein (g)	Fat (g)	CHO (g)	Na mEq	K mEq
CESEC	2.78	10.09	2.40	0.05	-	0.05	0.01
VEGETABLE OIL	2.88	22.81	-	2.53	-	-	-
SUGAR	7.26	29.04	--	-	7.26	-	0.02
STARCH	8.20	29.01	-	-	7.02	0.03	0.02
CORN SYRUPSOLIDS	7.49	29.06	0.03	0.09	7.27	0.45	0.03
MINERAL MIX	1.787	-	-	-	-	2.00	3.00
TOTAL :		120.01	2.43	2.67	21.60	2.53	3.08
ENERGY DISTRIBUTION (%)		100	8.0	20	72	-	-

TABLE 8

DIGESTIBILITY PARAMETERS ON SIX CHILDREN RECEIVING CASSAVA: GARI 60142, AND CONTROL DIETS

	CASEC - PRE				GARI				CASEC - POST		
	$\bar{x}$	±	SD	"p"	$\bar{x}$	±	SD	"p"	$\bar{x}$	±	SD
Nitrogen Balance											
Absorption %	82.2	±	3.43	NS	76.6	±	4.5	NS	82.8	±	4.7
Retention %	33.2	±	6.15	NS	28.8	±	4.4	$p < 0.05$	40.8	±	4.88
Feces											
Wet Weight g/d	89.0	±	34.0	$p < 0.05$	211.5	±	87.4	$p < 0.05$	108.9	±	53.7
Dry Weight g/d	15.46	±	4.13	$p < 0.05$	23.76	±	3.52	$p < 0.05$	15.52	±	2.99
Energy											
Kcal/day	50.73	±	14.18	$p < 0.05$	94.8	±	18.2	$p < 0.05$	49.95	±	12.08
% Intake	5.58	±	1.54	$p < 0.05$	10.2	±	1.6	$p < 0.05$	5.20	±	1.31
Fat											
g/day	2.02	±	1.11	NS	2.02	±	0.05	NS	1.59	±	0.86
% Intake	9.96	±	4.97	NS	9.8	±	3.1	NS	7.68	±	4.44
Carbohydrate											
g/day	3.28	±	1.81	$p < 0.05$	12.4	±	2.7	$p < 0.05$	3.99	±	2.45
% Intake	2.06	±	1.12	$p < 0.05$	7.5	±	1.4	$p < 0.05$	2.28	±	1.29
Body Weight Gain											
g/day	27.1	±	13.27	NS	23.4	±	20.8	NS	37.18	±	24.65
g/kg/day	3.52	±	1.45	NS	2.86	±	2.83	NS	4.92	±	3.95
Serum Albumin											
Initial	3.77	±	0.46	NS	3.66	±	0.22	NS	3.42	±	0.21
Final	3.65	±	0.22	NS	3.42	±	0.21	NS	3.56	±	0.26
Difference g/d	0.08	±	0.44	NS	-0.23	±	0.26	NS	0.05	±	0.26

TABLE 9

DIGESTIBILITY PARAMETERS ON SIX CHILDREN RECEIVING CASSAVA : FARINHA 60142, AND CONTROL DIETS

	CASEC - PRE				FARINHA				CASEC - POST		
	$\bar{x}$	±	SD	"p"	$\bar{x}$	±	SD	"p"	$\bar{x}$	±	SD
Nitrogen Balance:											
Absorption %	82.8	±	4.6	$p < 0.05$	78.7	±	2.1	$p < 0.05$	81.3	±	1.6
Retention %	38.2	±	3.3	$p < 0.05$	32.0	±	4.0	$p < 0.05$	35.7	±	9.8
Feces											
Wet Weight g/d	103.2	±	61.1	$p < 0.05$	164	±	60.1	$p < 0.05$	122.0	±	39.5
Dry Weight g/d	15.0	±	4.17	$p < 0.05$	22.1	±	4.0	$p < 0.05$	18.9	±	1.29
Energy											
Kcal/day	49.0	±	15.1	$p < 0.05$	85.9	±	12.6	$p < 0.05$	68.3	±	15.6
% Intake	5.35	±	1.38	$p < 0.05$	8.58	±	0.6	$p < 0.05$	7.24	±	2.12
Fat											
g/day	1.95	±	1.35	NS	1.8	±	0.82	NS	2.52	±	2.03
% Intake	7.42	±	4.23	NS	6.54	±	2.3	NS	12.02	±	10.13
Carbohydrate											
g/day	4.21	±	2.68	$p < 0.05$	11.06	±	2.86	$p < 0.05$	4.53	±	1.64
g/kg/day	2.45	±	1.40	$p < 0.05$	5.44	±	2.37	$p < 0.05$	2.64	±	1.0
Body Weight Gain											
g/day	42.6	±	23.5	NS	31.5	±	11.46	NS	24.0	±	23.3
g/kg/day	5.9	±	3.8	NS	4.02	±	1.64	NS	3.0	±	3.1
Serum Albumin											
Initial	3.56	±	0.34	$p < 0.05$	3.44	±	0.19	NS	3.42	±	0.35
Final	3.44	±	0.20	NS	3.42	±	0.35	NS	3.68	±	0.21
Difference g/dl	-0.13	±	0.17	NS	-0.02	±	0.33	NS	0.20	±	0.25

TABLE 10

DIGESTIBILITY PARAMETERS ON SIX MALE CHILDREN PARTICIPATING IN THE CASSAVA STUDY: GARI vs FARINHA (60142 VARIETY)

	GARI			FARINHA			
	$\bar{x}$	±	SD	$\bar{x}$	±	SD	Paired "t" test
Nitrogen Balance:							
Absorption %	76.6	±	4.5	78.7	±	2.1	NS
Retention %	28.8	±	4.4	32.0	±	4.0	NS
Feces							
Wet Weight g/d	211.5	±	87.4	164.0	±	60.1	NS
Dry Weight g/d	23.8	±	3.5	22.1	±	4.0	NS
Energy							
Kcal/day	94.8	±	18.2	85.9	±	12.6	NS
% Intake	10.2	±	1.6	8.6	±	0.7	$p<0.005$
Fat							
g/day	2.0	±	0.7	1.8	±	0.8	NS
% Intake	9.8	±	3.1	6.5	±	2.3	NS
Carbohydrate							
g/day	12.4	±	2.7	11.1	±	2.9	NS
% Intake	7.5	±	1.4	5.4	±	2.4	NS
Body Weight Gain							
g/day	23.4	±	20.8	31.5	±	11.5	NS
g/kg/day	2.9	±	2.8	4.0	±	1.6	NS
Serum Albumin							
Initial g/dl	3.66	±	0.22	3.44	±	0.19	NS
Final g/dl	3.42	±	0.21	3.42	±	0.35	NS
Difference g/dl	-0.23	±	0.26	-0.02	±	0.33	NS

TABLE 11

DIGESTIBILITY PARAMETERS ON THREE CHILDREN RECEIVING CASSAVA: GARI 4 (2) 1425, AND CONTROL DIETS

	CASEC - PRE				GARI				CASEC - POST		
	$\bar{x}$	±	SD	"t"	$\bar{x}$	±	SD	"t"	$\bar{x}$	±	SD
Nitrogen Balance											
Absorption %	84.2	±	2.02	$p < 0.05$	78.5	±	0.5	$p < 0.05$	85.3	±	0.58
Retention %	37.0	±	5.29	$p < 0.05$	30.2	±	5.2	$p < 0.05$	45.3	±	5.13
Feces											
Wet Weight	94.0	±	41.41	$p < 0.05$	153.7	±	62.1	NS	115.0	±	49.69
Dry Weight	16.14	±	5.47	$p < 0.05$	23.49	±	7.6	NS	16.18	±	2.37
Energy											
Kcal/day	61.9	±	35.2	$p < 0.05$	91.19	±	29.5	NS	50.3	±	5.6
% Intake	6.19	±	1.95	NS	8.31	±	0.28	$p < 0.05$	4.72	±	1.03
Fat											
g/day	2.26	±	1.39	NS	1.9	±	0.77	NS	1.8	±	0.36
% Intake	9.73	±	3.54	NS	8.1	±	1.22	NS	7.7	±	2.02
Carbohydrate											
g/day	5.42	±	3.75	$p < 0.05$	11.7	±	3.8	NS	3.54	±	0.77
% Intake	2.87	±	1.27	$p < 0.05$	6.2	±	0.54	$p < 0.05$	1.97	±	0.92
Body Weight Gain											
g/day	43.7	±	25.4	NS	45.9	±	22.0	NS	37.8	±	19.15
g/kg/day	4.8	±	2.0	NS	5.64	±	3.31	NS	3.9	±	1.19
Serum Albumin											
Initial	3.84	±	0.14	NS	3.62	±	0.38	NS	3.42	±	0.26
Final	3.62	±	0.34	NS	3.42	±	0.26	$p < 0.05$	3.75	±	0.17
Difference g/dl	-0.22	±	0.36	NS	-0.20	±	0.59	NS	0.33	±	0.09

TABLE 12

DIGESTIBILITY PARAMETERS ON THREE CHILDREN RECEIVING CASSAVA: FARINHA 4(2) 1425, AND CONTROL DIETS

	CASEC - PRE				FARINHA				CASEC - POST		
	$\bar{x}$	±	SD	"p"	$\bar{x}$	±	SD	"p"	$\bar{x}$	±	SD
Nitrogen Balance											
Absorption %	84.2	±	2.36	$p < 0.05$	79.8	±	1.26	$p < 0.05$	85.7	±	3.51
Retention %	36.0	±	10.5	NS	31.3	±	3.78	$p < 0.05$	43.0	±	2.0
Feces											
Wet Weight	93.2	±	22.2	NS	181.5	±	80.5	$p < 0.05$	101.7	±	38.6
Dry Weight	17.1	±	3.45	$p < 0.05$	24.8	±	6.5	$p < 0.05$	16.3	±	5.6
Energy											
Kcal/day	56.8	±	16.7	$p < 0.05$	87.4	±	37.8	$p < 0.05$	65.0	±	32.8
% Intake	5.59	±	1.12	$p < 0.05$	9.2	±	1.1	$p < 0.05$	5.8	±	2.3
Fat											
g/day	2.6	±	1.7	NS	1.93	±	0.6	NS	2.2	±	1.4
% Intake	11.3	±	5.9	NS	7.97	±	2.1	NS	8.9	±	4.6
Carbohydrates											
g/day	3.5	±	0.9	$p < 0.05$	13.1	±	3.5	$p < 0.05$	4.0	±	3.3
% Intake	2.0	±	0.9	$p < 0.05$	6.9	±	0.8	$p < 0.05$	3.1	±	1.2
Body Weight Gain											
g/day	31.7	±	13.3	NS	45.9	±	18.6	NS	51.6	±	13.0
g/kg/day	3.8	±	2.0	NS	5.5	±	2.6	NS	5.9	±	2.4
Serum Albumin											
Initial	3.41	±	0.21	$p < 0.05$	3.83	±	0.28	NS	3.72	±	0.18
Final	3.83	±	0.28	NS	3.70	±	0.20	NS	3.69	±	0.27
Differential g/dl	0.42	±	0.14	NS	-0.11	±	0.26	NS	-0.02	±	0.22

TABLE 13

DIGESTIBILITY PARAMETERS ON THREE CHILDREN PARTICIPATING IN THE CASSAVA STUDY: GARI vs FARAINHA (4-2-1425)

	GARI			FARINHA			
	$\bar{x}$	±	SD	$\bar{x}$	±	SD	Paired "t" test
Nitrogen Balance							
Absorption %	78.5	±	0.5	79.8	±	1.3	NS
Retention %	30.2	±	5.2	31.3	±	3.8	NS
Feces							
Wet Weight g/d	153.7	±	62.1	181.5	±	80.5	NS
Dry Weight g/d	23.5	±	7.6	24.8	±	6.5	NS
Energy							
Kcal/day	91.2	±	29.5	87.4	±	37.8	NS
% Intake	8.3	±	0.3	9.2	±	1.1	NS
Fat							
g/day	1.9	±	0.8	1.9	±	0.6	NS
% Intake	8.1	±	1.2	8.0	±	2.1	NS
Carbohydrate							
g/day	11.7	±	3.8	13.1	±	3.5	$p < 0.05$
% Intake	6.2	±	0.5	6.9	±	0.8	NS
Body Weight Gain							
g/day	45.9	±	22.0	45.9	±	18.6	NS
g/kg/day	5.6	±	3.3	5.5	±	2.6	NS
Serum Albumin							
Initial g/dl	3.62	±	0.38	3.83	±	0.28	NS
Final g/dl	3.42	±	0.26	3.70	±	0.20	$p < 0.05$
Difference g/dl	-0.20	±	0.59	-0.13	±	0.26	NS

TABLE 14

CASSAVA STUDY : CHEMICAL COMPOSITION

		PERUVIAN - JUNGLE LYOPHILIZED	NIGERIAN 60142 GARI	NIGERIAN 60142 FARINHA	NIGERIAN 4 - 2 - 1425 GARI	NIGERIAN 4 - 2 - 1425 FARINHA
NITROGEN	mg/100g	204.98	144.41	126.26	213.2	202.32
PROTEIN	(N x 6.25)	1.28	0.903	0.789	1.333	1.264
FAT	%	0.58	0.15	0.17	0.28	0.22
MOISTURE	%	3.24	7.29	9.35	8.01	11.9
CRUDE FIBER	%	3.07	2.90	3.02	3.11	3.12
ASH	%	1.16	1.02	0.68	1.52	1.28
CARBOHYDRATE		90.67	87.737	85.991	85.747	82.216
SODIUM	mEq/100g	0.7	0.61	0.84	0.64	0.87
POTASSIUM	mEq/100g	12.5	12.75	9.8	15.6	14.35
ENERGY	Kcal/100g	395.9	380.9	368.9	366.4	361.3
HCN	p.p.m.	66.6	2.6	3.4	3.0	1.8

TABLE 15

CASSAVA STUDY

VIRIETY * PROCESS	PERUVIAN (JUNGLE) LYOPHILIZED	NIGERIAN 60142 GARI a	NIGERIAN 60142 FARINHA b	NIGERIAN 4 - 2 - 1425 GARI c	NIGERIAN 4 - 2 - 1425 FARINHA d
NITROGEN BALANCE:	$\bar{x}$ SD	$\bar{x}$ SD	$\bar{x}$ SD	$\bar{x}$ SD	$\bar{x}$ SD
Absorption %	79 ± 5.1	76.6 ± 4.5	78.7 ± 2.1	78.5 ± 0.5	79.8 ± 1.3
Retention %	31 ± 7.8	28.8 ± 4.4	32.0 ± 4.0	30.2 ± 5.2	31.3 ± 3.8
FECES:					
Wet Weight g/d	196 ± 44.1	211.5 ± 87.4	164.0 ± 60.1	153.7 ± 62.1	181.5 ± 80.5
Dry Weight g/d	23.8 ± 3.8	23.8 ± 3.5	22.1 ± 4.0	23.5 ± 7.6	24.8 ± 6.5
FAT:					
g/day	1.9 ± 1.1	2.0 ± 0.7	1.8 ± 0.8	1.9 ± 0.8	1.9 ± 0.6
% Intake	8.0 ± 4.2	9.8 ± 3.1	6.5 ± 2.3	8.1 ± 1.2	8.0 ± 2.1
CARBOHYDRATE:					
g/day	11.2 ± 1.9	12.4 ± 2.7	11.1 ± 2.9	11.7 ± 3.8	13.1 ± 3.5
% Intake	6.0 ± 1.1[a]	7.5 ± 1.4	5.4 ± 2.4	6.2 ± 0.5	6.9 ± 0.8
ENERGY:					
Kcal/day	89.1 ± 16.2	94.8 ± 18.2	85.9 ± 12.6	91.2 ± 29.5	87.4 ± 37.8
% Intake	9.5 ± 3.2	10.2 ± 1.6	8.6 ± 0.7	8.3 ± 0.3	9.2 ± 1.1
BODY WEIGHT GAIN:					
g/d	28.1 ± 19.9	23.4 ± 20.8	31.5 ± 11.5	45.9 ± 22.0	45.9 ± 18.6
g/Kg/day	3.0 ± 1.9	2.9 ± 2.8	4.0 ± 1.6	5.6 ± 3.3	5.5 ± 2.6
SERUM ALBUMIN:					
Initial g/dl	3.56 ± 0.36	3.66 ± 0.22	3.44 ± 0.19	3.62 ± 0.38	3.83 ± 0.28
Final g/dl	3.72 ± 0.40	3.42 ± 0.21	3.42 ± 0.35	3.42 ± 0.26	3.70 ± 0.20
Difference g/dl	0.22 ± 0.19[a,d]	-0.23 ± 0.26	-0.02 ± 0.33	-0.20 ± 0.59	-0.13 ± 0.26
	n = 8	n = 6		n = 3	

a = p 0.05 Lyophilized with Gari 60142

d = p 0.05 Lyophilized with Farinha 4 - 2 - 1425

* (each cassava variety process providing 50% of the total energy diet.)