AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523

BIBLIOGRAPHIC INPUT SHEET

FOR AID USE ONLY

1. SUBJECT CLASSIFICATION

A. PRIMARY: Public Health

B. SECONDARY: Nutrition

2. TITLE AND SUBTITLE

Dietary protein quality in infants and children: III. Prolonged feeding of cottonseed flour

3. AUTHOR(S)

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4. DOCUMENT DATE	5. NUMBER OF PAGES	6. ARC NUMBER
1970	5 p.	ARC

7. REFERENCE ORGANIZATION NAME AND ADDRESS

British-American Hospital, Department of Research, Lima, Peru

8. SUPPLEMENTARY NOTES *(Sponsoring Organization, Publishers, Availability)*

(In American Journal of Clinical Nutrition, v. 23, no. 2, p. 165-169)

9. ABSTRACT

Previous comparative metabolic studies were reported in which cottonseed flour (CSF) served as the only source of protein in the diet of convalescent malnourished infants and children. 1) Cottonseed flour from glandless cottonseed (CF-26) appeared to have the highest biological value, with azeotropic solvent-extracted flours (CF-21/27) approximating its value closely, and CSF prepared by heat processing and a screw-press extraction (CF-22) having a distinctly lower value. Although rates of weight gain and changes in serum albumin levels were reported, it was made clear that in such short-term studies they were not reliable indicators of protein quality, and that only the apparent nitrogen retentions were of significance. This report covers experiments with prolonged feeding of the same CSF's as the only source of dietary protein to some of the same and a few additional infants and children. The duration of the diet periods was such that rates of weight gain, increments in height (recumbent length), and changes in serum albumin levels could be considered indicators of dietary protein adequacy.

10. CONTROL NUMBER

PN-AAC-585

11. PRICE OF DOCUMENT

12. DESCRIPTORS

Children
Cottonseed
Diets
Flours
Growth
Infants
Protein metabolism

13. PROJECT NUMBER

14. CONTRACT NUMBER

CSD-1433 Res.

15. TYPE OF DOCUMENT

AID 590-1 (4-74)

csd-1433 Rps
PN-AAC-585
612.348.6739m

THE AMERICAN JOURNAL OF CLINICAL NUTRITION
Vol. 23, No. 2, February, 1970, pp. 165-169
Printed in U.S.A.

Dietary Protein Quality in Infants and Children

III. Prolonged Feeding of Cottonseed Flour[1,2]

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WE RECENTLY REPORTED comparative metabolic studies in which cottonseed flour (CSF) served as the only source of protein in the diet of convalescent malnourished infants and children (1). Cottonseed flour from glandless cottonseed (CF-26) appeared to have the highest biological value, with azeotropic solvent-extracted flours (CF-21/27) approximating its value closely and a CSF prepared by heat processing and screw-press extraction (CF-22) having a distinctly lower value. Although rates of weight gain and changes in serum albumin levels were reported, it was made clear that in such short-term studies they were not reliable indicators of protein quality and that only the apparent nitrogen retentions were of significance.

This communication covers our experience with prolonged feeding of the same CSF's as the only source of dietary protein to some of the same, and a few additional, infants and children. The duration of the diet periods was such that rates of weight gain, increments in height (recumbent length), and changes in serum albumin levels could be considered indicators of dietary protein adequacy. We have used the progress in "height age" and "weight age" for each child as a measure of the adequacy of growth. Previously malnourished infants who are well advanced in their recovery gain weight easily (2) but lag in their linear growth (3).

METHODS

The source and characteristics of the CSF's used, the composition of the diets, the rationale for the dietary levels of protein and calories, and the composition of the vitamin and mineral mixtures have been reported (1). In contrast to the previous studies carried out under strict control in a metabolic unit, those being reported now were carried out in a more liberal convalescent unit where physical activity was unrestricted and the environmental temperature and humidity were not controlled. Except in those cases in which it is so stated, consumption of the diet was consistently complete or nearly so, but occasional spillage or vomitus was not measured. Height and weight ages are those to

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[2] Supported by Grants AM-01635, AM-09137, and AM-09980 from the National Institutes of Health, by Research Contract csd-1433 from the Agency for International Development, U. S. Department of State, and by a grant from UNICEF.

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TABLE I

Progress in height and weight ages and changes in serum albumin levels of infants and children consuming as their only source of protein a cottonseed flour

Case number and sex	Initial ages in months			Protein, g/kg per day	kcal		Progress in months			Serum albumin, g/100 ml	
	CA	HA	WA		per kg per day	% Protein	CA	HA	WA		Final
058, M	16.7	7.5	11.0	1.5	125	4.8	2.8	1.5	5.5	−0.23	3.70
058, M	20.0	9.5	14.5	1.5	100	6.0	2.0	2.0	3.5	0.36	3.63
058, M	22.0	11.5	18.0	3.0	100	12.0	0.7	0.5	1.5	0.02	3.65
053, F	11.0	7.0	10.0	2.0	125	6.4	2.0	1.5	1.5	0.50	4.52
053, F	13.0	8.5	11.5	5.0	125	16.0	2.0	1.0	−1.5	−0.76	3.76[a]
059, F	13.5	8.0	9.0	2.0	125	6.4	2.3	3.0	3.0	0.04	3.80
059, F	15.8	11.0	12.0	5.0	125	16.0	1.7	0.5	2.0	0.73	4.53
061, M	11.0	5.5	8.0	2.0	125	6.4	1.0	0.7	0.2	0.71	4.29
043, F	23.0	12.5	21.0	2.0	100	8.0	2.0	1.0	1.0	−0.15	3.58
051, M	36.5	19.5	20.0	2.0	100	8.0	1.0	0.5	3.5	−0.24	4.26
Mean	18.3	10.1	13.5	2.6	115	9.0	1.8	1.2	2.0	0.10	3.97
SD							0.7	0.8	2.0	0.48	0.38
SEM							0.2	0.3	0.6	0.15	0.12

Cottonseed flour, CF-22, made by heat processing and screw press extraction. Duration of diet periods is indicated by the change in chronologic age.

HA = height age, WA = weight age, CA = chronologic age.

[a] Anorexia and incomplete consumption of diet.

which the actual measurements correspond on the 50th percentile of a well-known United States standard (4). If a particular child, rehabilitated on a generous milk-based diet, does not gain in height at the rate of this standard, it is generally the result of a lesser genetic potential or one that has been impaired by the previous malnutrition (3).

The mean duration of exclusive CSF-protein feeding in the 14 children was 4.4 months (1.5–8.6 months), but the mean duration of the 25 periods reported was 2.4 months because some children received the same CSF at two or more different levels or received two different CSF's consecutively.

RESULTS

Tables I–III summarize the experience with the three different types of CSF. Although the mean ages of the children were similar, those receiving CF-22 were further along in their recovery and those receiving CF-26 were the least advanced. The mean durations of the diet periods for CF-21/27 (3.0 months) and for CF-26 (2.9 months) were longer than for CF-22 (1.8 months). The mean calorie intakes (in calories per kilogram body weight per day) were very similar for the three CSF's, but the mean protein intake for CF-22 was higher, and as a result, so was the percentage of dietary protein calories. The slightly higher protein and calorie intakes of those receiving CF-26, when compared with CF-21/27, were primarily a function of their less-advanced recovery.

In all three groups the gains in height age were less than would have been expected during the time elapsed, but as already indicated, this is characteristic of these severely malnourished mestizo children. The mean monthly gain in height age on CF-22 was 0.7 month; on CF-21/27 it was 0.77 month, and on CF-26 it was 0.86 month. Although suggestive, the differences are not statistically significant.

TABLE II

Progress in height and weight ages and changes in serum albumin levels when azeotropic solvent-extracted flours, CF-21 or CF-27, were the source of protein

Case number and sex	Initial ages in months			Protein, g/kg per day	kcal		Progress in months			Serum albumin, g/100 ml	
	CA	HA	WA		per kg per day	% Protein	CA	HA	WA	Δ	Final
058, M	13.6	4.5	8.0	1.5	125	4.8	3.1	3.0	3.0	−0.49	3.93[a]
095, F	8.0	4.5	1.5	2.0	160	5.0	1.7	1.8	4.0	−0.98	3.86
095, F	9.7	6.3	5.5	2.0	125	6.4	4.2	3.2	7.8	1.00	4.86
063, M	36.0	14.0	9.0	1.6	108	6.0	1.7	0.6	2.0	−0.65	3.90
061, M	8.0	3.5	2.5	2.1	131	6.4	3.0	2.0	5.5	−0.37	3.58
051, M	32.0	17.5	12.5	2.0	100	8.0	4.1	4.0	7.5	−0.57	4.50
056, M	33.0	13.0	12.5	2.0	100	8.0	4.9	1.5	9.0	−0.57	4.50
043, F	19.0	8.5	15.5	2.0	80	10.0	2.3	2.5	3.5	−0.12	4.00
043, F	21.3	11.0	19.0	2.0	100	8.0	2.0	2.0	2.0	−0.27	3.73
Mean	20.1	9.2	9.6	1.9	114	6.7	3.0	2.3	4.9	−0.34	4.10
SD							1.2	1.0	2.6	0.56	0.42
SEM							0.4	0.3	0.9	0.19	0.14

HA = height age, WA = weight age, CA = chronologic age.
[a] Anorexia and incomplete consumption of diet.

TABLE III

Progress in height and weight ages and changes in serum albumin levels when a flour from glandless cottonseed, CF-26, was the source of protein

Case number and sex	Initial ages in months			Protein, g/kg per day	kcal		Progre s in months			Serum albumin g/100 ml	
	CA	HA	WA		per kg per day	% Protein	CA	HA	WA	Δ	Final
120, M	23.0	13.5	10.0	2.0	125	6.4	4.0	3.5	3.0	−1.31	3.55[a]
123, M	5.5	3.5	2.0	2.5	135	7.4	3.6	3.0	4.3	0.09	4.15
125, M	7.3	1.5	2.0	2.7	150	7.2	3.1	2.5	4.5	−0.52	3.80
125, M	10.4	4.0	6.5	2.5	97	10.3	3.0	2.0	5.0	0.12	3.92
130, M	28.5	13.0	10.0	2.0	100	8.0	1.5	2.2	4.5	−0.71	3.57
135, M	33.0	17.0	14.0	2.0	100	8.0	1.9	1.0	3.0	0.26	4.34
Mean	18.0	8.8	7.4	2.3	118	7.8	2.9	2.4	4.1	−0.35	3.89
SD							1.0	0.9	0.9	0.61	0.32
SEM							0.4	0.4	0.4	0.25	0.13

HA = height age, WA = weight age, CA = chronologic age.
[a] Anorexia and incomplete consumption of diet.

Gains in weight age for the three groups exceeded the advances in chronologic age, again a characteristic of recovering malnourished children on adequate diets. The mean monthly gain in weight age on CF-22 was 1.15 months, on CF-21/27 it was 1.64 months, and on CF-26 it was 1.46 months. None of these differences was statistically significant, although that between CF-22 and CF-21/27 was most

suggestive. On the basis of their more advanced stage of recovery and similar calorie intakes per unit of body weight, the children receiving CF-22 should have gained more weight (2). The fact that they did not, despite higher protein intakes, is indicative of a lower biological value of the dietary protein.

Changes in serum albumin levels, although quite variable, were generally modest, and the final levels achieved were not significantly different. On CF-22, with a higher percentage of protein calories and less weight gain, serum albumin values were generally more stable than on the other CSF's, which supported higher rates of weight gain despite lower protein intakes.

Percutaneous liver biopsies were carried out in three of these infants after prolonged CSF feeding and were in each case normal to light microscopy. This was the case in *120* and *123* after 119 and 107 days, respectively, on CF-26, and in *058* after 287 days on CSF as the sole source of dietary protein, 91 on CF-21 and 193 on CF-22.

In three children, *123*, *125*, and *135*, a pellagroid dermatitis developed after being on CF-26 for a number of weeks. This did not affect growth and was shown to be unrelated to niacin or tryptophan intakes. Preliminary observations now suggest that it was due to the absence of zinc in the mineral mixture.

DISCUSSION

Most of the children in this study received one of three CSF's at critical dietary protein levels, well below those proposed for actual use of each flour (1). The fact that serum albumin usually remained at satisfactory levels, even in the case of the CSF of lowest biological value, is probably due to the lower rate of weight gain, as has been documented previously (5). It seems most likely that this was achieved by fat deposition and an increase in the specific dynamic action of the diet (6). Our previous studies, and observations in these children, give no indication of increased stool losses, which might explain the apparent loss of energy.

Although differences were not statistically significant, the superior rates of linear growth and weight gain on CF-26, -21, and -27, despite lower protein intakes and less advanced state of nutritional recovery of the subjects, are confirmatory of the higher biological value found by the nitrogen-balance technique in the same, or similar, infants and children. These studies also confirm the suggestion that at adequate levels of intake properly processed cottonseed flours can serve as the main or only source of dietary protein for rapidly growing infants and children. This has also been demonstrated with INCAP mixture 9, which depends almost exclusively on CSF for its protein (7). The final levels of serum albumin were generally lower than those characteristic of similar children on milk diets, but only slightly so.

SUMMARY

Prolonged feeding trials confirm the impression gained from metabolic studies that properly processed cottonseed flours, at adequate levels, can serve as the main or only source of protein for rapidly growing infants and children.

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