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~~APPENDIX IV-C~~

TO: Dr. Samuel G. Kahn
Science Research Officer
Office of Nutrition
Agency for International Development
Washington, D.C. 20523

FROM: Instituto de Investigacion Nutricional
Apartado 55
Miraflores (Lima), Peru

and

George G. Graham, M.D. &
William C. MacLean, Jr., M.D.
615 North Wolfe Street
Baltimore, Maryland 21205

SUBJECT: SUBSTANTIVE PROGRESS REPORT
AID Contract ta-C-1286
CLINICAL ASSAY OF HIGH PROTEIN FOODS
March 1, 1978 - April 15, 1979

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This program, Clinical Assay of High Protein Foods (AID ta-C-1286), was formally reviewed by AID on April 3, 1978. At that time, a substantive progress report of all work carried out directly under or facilitated by the contract was submitted by the contractor to AID. This is found in Appendix 1. The present report covers work done between March 1, 1978 and April 15, 1979.

I. Research Carried Out Directly Under Contract AID ta-C-1286.

A. Corn Soy Blend

These studies were carried out for a dual purpose. The first was to evaluate the quality of the protein in a 70/30 blend of degerminated corn and dehulled soy cooked on low-cost extruders. The second was to examine the digestibility by infants of 70/30 blends of whole corn and dehulled soy (CSB#2) and whole corn-whole soy (CSB#3).

In the first part of the study the 70/30 blend of degerminated corn and dehulled soy (CSB#1) was compared with casein at a critical 6.4% protein-calories in nine convalescent malnourished male infants. In the second part of the study the same nine infants received all three blends in consecutive periods, each providing 50% of total calories in the diet and 100% of the 8.36 to 8.72% protein-calories.

The first phase of the studies confirmed the high nutritional value of the degermed corn-dehulled soy blend represented by CSB#1. As a percentage of absorbed nitrogen the apparent retentions of nitrogen (biologic values) were as high as those found with instant CSM and the best cereal-

legume combinations we have evaluated. Nitrogen absorption was the limiting factor and was low enough to affect significantly the retention of nitrogen by two infants.

The results with CSB#2 and CSB#3 were very definitely inferior to those from CSB#1 and were in contrast to the equivalent nutritional value found in rats. This was undoubtedly due to the less efficient digestive function of the young human being. The inferiority of these two blends was significant enough to call for great caution in using either one to replace the product made from degermed corn and dehulled soy (CSB#1).

A full description of these studies and their results was submitted to AID on January 29, 1979, and is found here as Appendix 2.

B. Maize

Endosperm and whole kernel maize meals from three different 3-way hybrids were made available by Dr. David Glover of Purdue University. A Sugary 2 - Opaque 2 variety was developed to overcome some of the acceptability problems of Opaque 2 but studies by Dr. Helen Clark suggested inferior digestibility of its carbohydrates by adults. The digestibility and utilization of these two high-lysine, high-tryptophan varieties was compared with that of normal maize, both as the commonly consumed whole kernel meal and as endosperm meal, in recovered malnourished children 12 to 25 months of age. It is currently fashionable to accept the claim that if children eat enough of their staple food to satisfy most of their energy needs, not an easy task, they will automatically meet their

protein requirements. The large amounts of maize that were fed in these studies allowed us to examine this hypothesis.

The three endosperm meals were fed consecutively to six subjects in six different sequences, preceded and followed by casein-based diets. The same protocol was followed for whole kernel meals. Four children participated in both studies. All diet periods were of nine days, with 3 for adaptation and 6 for metabolic collections. All diets were isocaloric and isonitrogenous for each child. Intakes were 100 to 125 Kcal/kg/day and had previously been demonstrated to support steady weight gain. Protein represented 6.4% and fat 10% of energy in all diets. Minerals and vitamins were supplied to meet or exceed recommended allowances.

Absorptions of nitrogen from all three endosperm meals were similar and significantly less than from casein. Apparent retention of nitrogen from Opaque 2 - Opaque 2 and Sugary 2 - Opaque 2 was markedly superior to that from normal maize, but even if these children had consumed 100% of energy needs from maize in this form they would have been far short of meeting their protein needs.

When whole kernal meals were compared, apparent nitrogen absorptions from all three maizes were similar. Apparent nitrogen retentions from normal maize were expectedly inferior, but not so strikingly so as from the endosperm meals. If these children had consumed 90+% of dietary energy from opaque 2 or 85+% as Sugary 2 - Opaque 2, and the same percent nitrogen retentions had held, they could conceivably have satisfied their protein needs.

In all studies nitrogen retention related directly to the amount of lysine apparently absorbed. This in part explained the superiority of whole kernal meals over endosperm meals, although smaller losses of energy in the stool during consumption of the whole kernal meals may also have been important.

Many children already depend on maize as the main if not only source of protein. For them there are obvious advantages of whole kernal over endosperm meal, especially with opaque-sugary varieties. A full presentation of these results has been sent to AID (April 11, 1979) and is found as Appendix 3.

C. Sorghum

In 1966, USAID began supporting research at Purdue University directed at the improvement of protein quality and content, digestibility and yield of sorghum. Wide variability in protein content, amino acid composition and digestibility of different sorghums offered the promise of improving all three aspects as they related to human nutritional requirements.

The current studies were undertaken to evaluate the protein quality and digestibility in children of 4 varieties of sorghum made available by Purdue University. Young children have the highest relative nutritional requirements and the most limited digestive capacities and consequently represent the major nutritional problem for most countries. If staple foods of improved protein quality and digestibility are to help in the alleviation of malnutrition around the world, they must be able to be consumed and utilized by this age group. For this reason, this form of human testing under the carefully

monitored conditions of a metabolic ward is an important part of such breeding improvement programs.

Two lower protein (11.5% and 12.7%) low lysine (2.1 and 2.2 g. lysine/100 g. protein) sorghums and two high protein-high lysine varieties (P721-0P9: 13.6% protein, 3.0 g. lysine, and IS11758: 15.8% protein, 2.9 g. lysine) are under study. To date the evaluation of only one low protein and one high protein variety has been completed. The results of 18 balance studies in 9 children gave a picture during sorghum consumption of very poor absorption and very low retention of nitrogen. Overall energy digestibility was equally poor; fecal weights and energy losses were excessive. Increasing cooking time and liberalizing the protein intakes from sorghum did not improve results. The problems of bulkiness, poor protein quality and poor digestibility with sorghum were greater than with any food or food blend evaluated by us during the past 17 years. Although appropriately processed sorghum has been shown to be useful as part of some food blends (Thriposha, for example) direct consumption of significant quantities by children cannot be expected to have a beneficial nutritional effect and should be discouraged. Consumption of any of the major staples (wheat, rice, corn or potato) would be far preferable if it were or could be made available. A full report of the methods, results and recommendations from these studies to date is found in Appendix 4.

II. Additional Research Facilitated by Contract ta-C-1286.

A. Studies with Wheat Noodles in Infant Nutrition.

Short term balance studies to determine the tolerance to and digestibility of wheat as noodles are now completed. Nine infants, 7-18 months of age, consumed diets in which pasta provided 25%, 50% and 75% of energy. Protein provided 6.6% of calories in the 25% pasta (casein-wheat protein in equal amounts) and 50% pasta diets (100% wheat protein). The 75% pasta diet provided 9.8% of energy as wheat protein. Balance studies were carried out during the last six days of seven nine-day dietary periods. Appropriate isoenergetic-isonitrogenous casein control periods separated pasta periods. Apparent N retention during consumption of a 50:50 mixture of casein and wheat protein equalled that of casein alone. Apparent N retention during consumption of pasta at 9.8% protein-energy was inferior to casein in 5 children, similar in 3 children and superior in only one. Digestibility of wheat at all three levels of intake was excellent. Apparent N absorption did not differ from casein. Analysis of variance showed no effect of consumption of increased amounts of wheat on apparent N absorption of stool wet weight. A linear relation to fecal energy and fecal carbohydrate content was found. Although the latter relationships were highly significant statistically, the incremental loss of energy in the stool at 75% pasta over 50% pasta was less than 3% of total energy intake, a value of minor biological significance.

These studies clearly documented that pasta can readily

provide a substantial proportion of the energy and protein in the diets of infants. Because of wheat's excellent digestibility it should be a valuable weaning food in developing countries. Without lysine supplementation however, it cannot satisfy the protein needs of these infants. These studies are to be published shortly in the Journal of Nutrition and are fully described in Appendix 5.

B. Nutritive Value of Brown and Black Beans.

The value of legumes as protein and lysine supplements to cereal and root-based diets is recognized by the scientific community and by the many millions of people throughout the underdeveloped world who traditionally consume them in combination with cereals, roots, and starchy foods. These same people tend to withhold the legumes from the diets of weaned infants and small children, "presumably" contributing to the development of protein deficiency in this age group. Nevertheless, their increased consumption is widely recommended for infant and child feeding in poor societies.

We have tried, unsuccessfully, to find in the literature adequate documentation of the nutritive value of common legumes for infants and small children, particularly of their ability to digest the protein and energy. Prompted by concern over the lack of scientific backing for recommendations that involve millions of children we completed analysis during the past year of studies carried out over five years ago.

A precooked, instantized mixture of brown and black beans, with and without 0.3% DL-methionine added, served as the only

source of protein in the diets of 10 recovered malnourished infants and children, 10 to 42 months of age. At 6.4-6.7% dietary protein calories stool, wet weights were twice as high, apparent N absorption significantly lower (65.6±5.9 vs. 87.5±2.3% of intake), and apparent N retention much lower (9.8±6.1 vs. 34.5±10.2% of intake) than during preceding and following isocaloric and isonitrogenous casein based diets. The addition of methionine resulted in minimal improvement in N retention and a highly suggestive increase in fasting plasma free methionine. Prolonged feeding of the methionine-enriched beans at 8.0-10.0% protein calories supported satisfactory growth and serum albumin levels in two of three children, not so in the smallest one, in whom repeated balance studies demonstrated no decrease over time in stool wet weight and only marginal improvement in N absorption and retention. The poor digestibility of the protein in these beans was the first-limiting factor in its utilization by infants and small children.

These limited studies with one legume processed in a particular fashion can obviously not be used to make generalizations about all legumes, but because the beans used are those with most widespread consumption, the results call for caution in making recommendations about legume consumption by the very young. They also lend support to the misgivings most poor mothers express about the feeding of legumes to very young children. It may well be necessary to process legumes more extensively, as in the case of the soybean, before they can be fed safely and profitably to most infants and small children.

A full report of this work is located in Appendix 6 and has been accepted for publication in the American Journal of Clinical Nutrition.

C. Nutritive Value of the Potato.

During the past several years we have been carrying out studies on the value of the white potato in infant nutrition in conjunction with the Centro Internacional de la Papa (C.I.P., International Potato Center), located in Peru. Nitrogen balance studies at critical levels of protein intake have shown an apparent absorption of nitrogen of 66±4%. an apparent retention of nitrogen of 34±6%. These values were 79% (absorption) and 77% (retention) of those for a casein control diet. The apparent biological value (the percentage of absorbed nitrogen retained) of potato protein did not differ from casein. Variability of nitrogen content of the potato was a problem and the studies carried out to date were unable to define whether this related to growing conditions or to processing.

In studies in which potato intake was increased from 25% to 50% to 75% of calorie intakes, there was no effect of increasing potato consumption on the apparent digestibility of potato protein. In contrast, consumption of increasing amounts was associated with an increase of stool wet and dry weight and of energy lost in the stool. This problem with carbohydrate digestibility is perhaps the most serious with regard to using potato as a weaning food. Food processing technology may be able to solve some of this.

Complete analysis of our results is currently underway. A preliminary analysis has suggested new areas of collaborative research between the Nutrition Research Institute and the International Potato Center. A proposal for further collaboration and a more complete summary of results to date with potato are found in Appendix 7.