AN ASSESSMENT OF THE NUTRITIVE VALUE OF 'MULTI-PURPOSE FOOD' (FORMULA C) IN THE TREATMENT OF CONVALESCENT KWASHIORKOR PATIENTS

P. J. PRETORIUS, M.MED. (PAED.), M.D., *National Nutrition Research Institute, South African Council for Scientific and Industrial Research, Pretoria, and Department of Paediatrics, University of Pretoria*

On behalf of Meals for Millions, Inc., Los Angeles, USA, the efficacy of maize meal diets containing Multi-purpose Food (Formula C) with and without added vitamin supplements was compared with that of dried skimmed milk in the treatment of convalescent kwashiorkor patients.

The world-wide recognition of the prevalence of malnutrition among infants and young children in indigent population groups has led to an intensive investigation of the possibilities of producing cheap protein foods and food mixtures for distribution or sale among the underprivileged. The foods investigated have included skimmed milk powder, fish flour, various soya preparations, mixtures of pulses and cereals and various other food combinations too numerous to mention and reported on in an extensive volume of scientific literature. One of the better-known of these preparations, Incaparina, consists entirely of vegetable ingredients and has been used with wide success in Guatemala. The development of this food mixture is reviewed in a recent publication by Neser and Pretorius,[1] which also discusses numerous other foods and food mixtures, including some of those at present being manufactured in South Africa, and examines in detail the principles on which the formulation and evaluation of food mixtures should be based.

It is recommended by these authors that the evaluation of foods and food mixtures for the prevention of malnutrition in young children should include chemical analyses, biological evaluation of the protein by means of animal experiments, clinical investigation including balance studies, and field trials to test the acceptability of the food.

The present paper describes a typical clinical investigation of a food formulated for use in the prevention of malnutrition. The experimental procedure described is similar to that previously employed by the National Nutrition Research Institute in the evaluation of fish flour[2] and other foods regarded as potential weapons against malnutrition in infants and young children.

A second report will be published in due course which describes the chemical analyses (including aflatoxin determinations), the biological and bacteriological evaluations and the organoleptic tests on Whites and non-Whites carried out to complete the evaluation of this food.

MATERIALS AND METHODS

Thirty-six convalescent kwashiorkor patients, free from active tuberculosis or acute infection, were divided at random into 2 experimental groups and a control group.

The investigations were commenced on all patients exactly 5 weeks after admission to hospital. At this stage all overt signs of kwashiorkor with the exception of hair changes and growth impairment had disappeared.

During the experimental period of 4 weeks the patients were weighed and examined every day. Blood was taken on the first day of the trial period and thereafter at weekly intervals for the estimation of various serum constituents.

Composition of the Diets (Tables I and II)

TABLE I. PERCENTAGE COMPOSITION OF THE DIETS (DRY INGREDIENTS)

Ingredients	*MPF-diet*	*Skimmed-milk diet*
Sifted granulated maize meal ..	55·6	55·6
MPF	13·9	
Dried skimmed milk		16·7
Maize starch	13·8	11·0
Cane sugar	16·7	16·7

1. *Multi-purpose food (MPF) diet.* The basic ingredient was sifted, granulated maize meal (Table I). The maize meal was supplemented, on a dry basis, with 13·9% MPF. No vitamin supplements were added.

2. *Multi-purpose food and vitamin supplement* (MPF + VS). The diet was identical with that described above, except that all patients in this group received in addition a daily supplement of a multi-vitamin preparation.

3. *Skimmed milk (control) diet.* As in the case of the experimental diets, the control diet contained 55·6% maize meal. This was supplemented with 16·7% dried skimmed milk (Table I). The patients in this group also received the multi-vitamin supplement daily and since the diet was a very poor source of iron, 0·4 G of ferrous sulphate per day was added.

The MPF contained 46% and the dried skimmed milk 34% protein (Table II). These ingredients were added in different proportions and the protein content of the diets did not differ

materially. Sugar was added in equal proportions and maize starch in proportions so adjusted as to ensure an equal calorie content. In order to meet recommended requirements, 2 G of sodium chloride were added to the diets.

TABLE II. CHEMICAL COMPOSITION OF THE INGREDIENTS OF THE DIETS

	MPF	*Dried skimmed milk*	*Maize meal*	*Maize starch*
Moisture (%)	6·96	4·62	13·51	11·93
Protein (%)	46·17	34·06	8·54	0·32
Fat (%)	0·77	0·56	3·65	0·39
Ash (%)	7·14	8·23	1·05	0·06
Calcium (mg./100 G)	880	1,148	3·73	14·3
Magnesium (mg./100 G)	216	117	90·3	4·63
Phosphorus (mg./100 G)	765	1,017	221	14·0
Iron (mg./100 G)	5·69	0·93	2·55	2·08
Copper (mg./100 G)	1·37	0·05	0·21	0·0
Sodium (mg./100 G)	131	5·08	0·27	3·27
Potassium (mg./100 G)	2,082	1,770	294	6·46
Vitamin A (IU/100 G)	2,411			
Thiamine (mg./100 G)	1·0	0·5	0·47	
Riboflavine (mg./100 G)	1·6	2·1	0·14	
Niacin (mg./100 G)	18·3	0·8		
Vitamin C (mg./100 G)	81·2			

The total weight of dry ingredients prescribed was in each case 36 G/kg. bodyweight/day. The dry ingredients were mixed with water, the prescribed amount of water for each patient being 180 ml./kg. bodyweight/day. The mixture was cooked for about 20 minutes and served as a thickish porridge. The diets provided a protein intake of about 4 G/kg. bodyweight/day.

Balance Studies

Nitrogen balance studies were carried out on 4 male patients from each group. The studies were commenced during the 2nd week of the experimental period.

In 7 of the 12 patients the balance studies were repeated after completion of the experiment. During the pre-balance period of 1 week and during the balance period, the protein content of the diets was lowered by about 40% by replacing some of the maize meal and some of the MPF with isocaloric amounts of maize starch. This was done because differences in the quality of dietary proteins which can be detected at lower levels of intake may not be apparent at higher levels.[3]

Analytical Methods

The methods used for the estimation of the various serum constituents were identical with those described in a previous report,[2] and the nitrogen in the food, urine and stools was determined according to the standard methods in use at the National Nutrition Research Institute.

Statistical Methods

A two-way analysis of variance[4] was applied separately both to the initial values and to the difference between the initial and the final values for each of the following entities: weight, serum albumin, serum globulin, serum cholesterol, serum amino nitrogen and blood urea. The purpose of this test was two-fold, viz. (1) To test whether the 3 diets produced the same effect on the patients, and (2) to test whether patients in the 1 - 2 year age-range reacted differently from patients in the 2 - 3 year age-range (irrespective of the diet given).

RESULTS

The study was completed on 29 of the 36 patients in the 3 groups. In 7 of the patients the diets were discontinued before the completion of the experimental period because of the development of various infections. Two patients developed measles, 2 gastroenteritis, 2 bronchopneumonia and the 7th patient became ill with acute follicular tonsillitis. These cases have been excluded from the consideration of the findings. Of the remaining 29 patients who completed the experimental period, 10 belonged to the MPF group, 11 to the MPF + VS group and 8 to the skimmed-milk (control) group.

Clinical Results

The mean age of the MPF-group was 20 ± 4·3 months, that of the MPF + VS group 20 ± 6·9 months and that of the skimmed-milk group 22 ± 4·9 months. The differences were not statistically significant, i.e. the 3 samples can be considered to have been drawn from the same age-range.

All 3 diets were well accepted and tolerated. In no instance was it necessary to discontinue any of the diets before the end of the trial period because of poor appetite or intolerance. It should be re-emphasized that the reason for discontinuing the diets in 7 patients was the development of infections.

TABLE III. WEIGHT GAIN DURING THE TEST PERIOD

Group	*Weight (kg.)*		
	Initial (Mean±SD)	*Final (Mean±SD)*	*Gain (Mean±SD)*
MPF group	8·99±1·413	9·86±1·833	0·87±0·591
MPF+VS group	8·81±1·140	9·50±1·394	0·69±0·749
Skimmed-milk group	8·66±1·164	9·78±1·195	1·12±0·415

As can be seen from Table III, weight gain was satisfactory in all 3 groups although the average gain was less in the MPF + VS group than in the other 2 groups. The differences between the 3 groups were not statistically significant, and no differences dependent on age could be demonstrated.

Changes in the levels of certain serum constituents. The changes in the levels of the serum constituents determined during the course of the experiment are summarized in Table IV. With the exception of serum globulin, the concentrations of those constituents listed in the table are low in acute kwashiorkor.[5,6] A decrease in the levels of these constituents might, therefore, possibly reflect a deterioration in the condition of a patient due to an unsatisfactory diet, but it should be borne in mind that the reduction in protein and fat intake during the experimental period might also affect the levels of certain constituents.

The initial values of the serum constituents in the 3 groups did not differ significantly and, except in the case of the changes in serum albumin, which differed significantly in the MPF and MPF + VS groups, there was no significant difference between the 3 groups in respect of

TABLE IV. LEVELS OF CERTAIN CONSTITUENTS IN THE SERUM DURING TEST PERIOD

Serum constituent	*Dietary group*	*Initial value (Mean±SD)*	*Final level (Mean±SD)*	*Mean change over test period (mean)*
Serum albumin (G/100 ml.)	MPF	3·4±0·71	3·5±0·44	0·1
	MPF+VS	4·0±0·32	3·3±0·33	—0·6
	Skimmed milk	3·7±0·42	3·3±0·49	—0·4
Serum globulin (G/100 ml.)	MPF	3·5±1·12	3·0±0·46	—0·5
	MPF+VS	2·9±0·40	3·1±0·41	0·2
	Skimmed milk	3·6±0·49	3·4±0·49	—0·2
Urea (mg./100 ml.)	MPF	22±7·9	14±3·1	—8
	MPF+VS	20±4·1	15±4·2	—5
	Skimmed milk	21±6·1	13±2·9	—7
Cholesterol (mg./100 ml.)	MPF	213±47·9	174±23·3	—39
	MPF+VS	194±37·9	149±37·6	—45
	Skimmed milk	188±25·6	172±21·0	—16
Amino nitrogen (mg./100 ml.)	MPF	2·8±0·83	2·7±0·78	—0·1
	MPF+VS	3·2±1·09	2·9±0·76	—0·2
	Skimmed milk	2·8±0·42	2·9±0·47	0·1

any of the changes in the levels of the serum constituents. No effects dependent on age could be demonstrated. It should, however, be pointed out that significant differences might well have been found for any of the variables tested if the number of patients in each group had been larger.

It is difficult to account with certainty for the statistically significant difference between the MPF and MPF + VS groups in respect of the change in serum albumin. The only difference in the 2 diets was that the patients in MPF + VS group received additional vitamins. That this could have been responsible for the difference seems highly improbable. It is of importance to bear in mind, however, that, although the initial values of the 3 groups did not differ significantly, there was nevertheless a considerable difference between the MPF and MPF + VS groups in respect of the initial values.

A considerable decrease in *serum cholesterol* and *blood urea concentration* occurred in all 3 groups, but the differences between the groups were not significant. These decreases were almost certainly not indicative of a deterioration in the nutritional state of the patients, but probably reflected the diminished intake of fat and protein during the experimental period. Similar observations have been made previously in patients receiving maize diets containing fish flour or skimmed milk.[2]

Nitrogen balance results. The balance results are given in Tables V and VI. Because of the limited number of patients studied, the results obtained in the 3 groups of patients were not subjected to statistical analysis.

No striking differences were observed between the 3 groups. Values for retention were high in all 3 groups and no negative balances occurred in any of the patients. The protein in all 3 diets was therefore utilized very well in spite of some impairment in the apparent absorption of nitrogen, especially on the lower protein intakes (Table VI).

The possible reasons for the low values for apparent absorption regularly observed in patients receiving predominantly maize diets have been discussed in detail in a previous report.[2] The main factor is probably the high excretion of metabolic nitrogen which has been observed in African children.[7] It has also been found that in convalescent kwashiorkor patients the digestibility of the protein is lower in the case of diets containing maize meal than in milk diets.[8] The lowered protein intakes are presumably responsible for the even lower percentage values obtained during the second balance periods.

SUMMARY AND CONCLUSIONS

The efficacy of maize meal diets containing supplements of Multi-purpose Food (MPF), Multi-purpose Food with additional vitamins (MPF and VS) and dried skimmed milk in the treatment of convalescent kwashiorkor patients was compared in 36 patients divided at random into 3 groups, of whom 7 were later excluded because they developed incidental infections.

All 3 diets were taken and tolerated very well. In no instance was it necessary to discontinue any of the diets before the end of the 4-week trial period because of food intolerance.

The 3 groups of patients were compared as regards weight gain and changes in the protein, urea, cholesterol and amino nitrogen levels in the blood serum. With the exception of the change in serum albumin concentration which differed significantly in the MPF and MPF + VS groups, no significant difference was found.

Three-day nitrogen balance studies were carried out in some of the patients from each group. No striking differences were observed in respect of retention and absorption of nitrogen. Because of the limited number of patients studied, the results were not subjected to statistical analysis. No negative balances occurred in any of the patients, values for retention being high in all 3 groups despite some impairment in the absorption of nitrogen.

No indication could be obtained from the results of the present short-term investigation carried out on a limited number of patients that the efficacy of MPF differed from that of skimmed milk in the treatment of convalescent kwashiorkor patients. It should be added that MPF has an advantage over skimmed milk in that it contains added vitamins and minerals.

The statistical planning and analysis of the results were carried out by Mr. S. A. Fellingham of the NRIMS (CSIR).

TABLE V. NITROGEN BALANCE RESULTS OBTAINED DURING THE FIRST BALANCE PERIOD

Patient	*Diet*	*Intake (mg./kg./day)*	*Urinary excretion (mg./kg./day)*	*Faecal excretion (mg./kg./day)*	*Retention (mg./kg./day)*	*Retention (as percentage of intake)*	*Absorption (as percentage of intake)*
E.M.	MPF	623	231	130	262	42	79
C.M.	MPF	591	194	154	243	41	74
B.M.	MPF	616	245	146	225	36	76
G.T.	MPF	598	122	98	378	63	84
	Mean	607	198	132	277	45	78
A.M.	MPF+VS	635	183	156	296	47	75
A.N.	MPF+VS	661	242	146	273	41	78
J.M.	MPF+VS	571	268	98	205	36	83
K.S.	MPF+VS	623	274	91	258	41	85
	Mean	623	242	123	258	41	80
J.N.	Skimmed milk	613	256	118	239	39	81
J.T.	Skimmed milk	428	141	128	159	37	70
F.M.	Skimmed milk	541	77	110	354	65	80
F.N. ..	Skimmed milk	468	162	132	174	37	72
	Mean	512	159	122	231	45	76

TABLE VI. NITROGEN BALANCE RESULTS OBTAINED DURING THE SECOND BALANCE PERIOD

Patient	*Diet*	*Intake (mg./kg./day)*	*Urinary excretion (mg./kg./day)*	*Faecal excretion (mg./kg./day)*	*Retention (mg./kg./day)*	*Retention (as percentage of intake)*	*Absorption (as percentage of intake)*
E.M.	MPF	356	100	66	190	53	81
B.M.	MPF	365	129	87	149	41	76
	Mean	360	114	76	170	47	79
A.M.	MPF+VS	347	103	169	178	22	51
A.N.	MPF+VS	371	83	172	199	25	54
J.M.	MPF+VS	369	144	87	282	37	76
	Mean	362	110	143	109	30	60
J.N.	Skimmed milk	343	78	139	126	37	59
J.T.	Skimmed milk	296	93	85	118	40	71
	Mean	319	85	112	122	38	65

Chemical analysis of the foodstuffs and nitrogen determinations of urine and faeces were carried out by the Division of Food Chemistry (Head, Mr. A. S. Wehmeyer) of the NNRI. The serum biochemical determinations were done by the Biochemical Laboratory (Head, Dr. L. S. de Villiers) of the Institute of Pathology, University of Pretoria. The report was edited by Dr. M. L. Neser of the NNRI.

REFERENCES

1. Neser, M. L. and Pretorius, P. J. (1964): *The Planning of Food Mixtures for the Prevention of Malnutrition*. NNRI Research Report. Pretoria: CSIR.
2. Pretorius, P. J. and Wehmeyer, A. S. (1964): Amer. J. Clin. Nutr., **14**, 147.
3. Scrimshaw, N. S., Béhar, M., Wilson, D., Viteri, F., Arroyava, G. and Bressani, R. (1961): *Ibid.*, **9**, 196.
4. Scheffé, H. (1959): *The Analyses of Variance*. New York: Wiley & Sons.
5. Trowell, H. C., Davies, J. N. P. and Dean, R. F. A. (1954): *Kwashiorkor*. London: Edward Arnold.
6. Pretorius, P. J. and De Villiers, L. S. (1961): S. Afr. J. Lab. Clin. Med., **7**, 108.
7. Demayer, E. M. and Vanderborght, H. (1958): J. Nutr., **65**, 335.
8. Hansen, J. D. L. (1961): In *Proceedings of an International Conference on the Effects of Various Forms of Supplementation on the Nutritive Value of Maize*. Washington, DC: National Academy of Sciences—National Research Council.