DRIED SKIMMED MILKS AND KWASHIORKOR

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In a previous investigation[1] concerning the dietary treatment of kwashiorkor, it appeared that an imported spray-dried acidified skimmed milk was superior to a local roller-dried skimmed milk in initiating cure. The imported milk, however, was supplied in air-proof and moisture-proof containers, whereas the roller-dried milk was packed in bags not impervious to moisture. The possibility that the Maillard reaction[2] had occurred in the latter case could therefore not be excluded. In this reaction, which occurs in the presence of excessive moisture, lysine and possibly other amino acids become inactivated. It was further pointed out that lactic acid was added during the manufacture of the spray-dried milk, whereas in that of roller-dried milk lactic acid was added at the time of preparation of the feeds.[1]

Another factor which may possibly have influenced the results obtained is that the majority of the patients who received the spray-dried milk were treated during the winter months, when infective diarrhoea is not a big problem. We have previously stressed the difficulty in establishing criteria of severity in kwashiorkor[1] and the possibility cannot be excluded that the patients who received the spray-dried milk may have been less severely affected than the patients in the other groups.

Since factors other than the method of manufacture of the dried skimmed milk might have been responsible for the good results obtained with the spray-dried milk it seemed desirable that the earlier results should be confirmed or clarified. The roller process is cheaper than spray-drying, especially in installation cost. At least 15,000 gallons of milk must be processed daily to make spray-drying economical. The erection of large spray-drying plants is thus limited by the supplies of milk available and by transport costs, a major economic consideration. Although roller-drying requires skilled attention for the operation of the driers, this process can be employed economically on a smaller scale (5,000 gallons per day).

As the incidence of protein malnutrition parallels that of poverty,[3] it seemed important to ascertain whether good-quality roller-dried skimmed milk is as effective in initiating cure of kwashiorkor as the more expensive spray-dried variety. The high temperature (about 250°F) prevailing on the drums in the roller process causes considerable denaturation of the protein although the product is exposed to this temperature for only about one second.[4] During this process lysine, and possibly to a lesser extent other amino acids as well, may be damaged.[4,5] During spray-drying heat treatment of the milk takes place at about 130°F and lasts only a fraction of a second.[4] Nevertheless, with the improvements which have been introduced from time to time, drum drying can yield a dried milk of high quality.[4]

MATERIAL AND METHODS

The criteria used in the selection of patients were identical with those described previously.[1,6] Sixty patients suffering from kwashiorkor were divided at random into 3 equal groups, one of which received roller-dried skimmed milk, another spray-dried skimmed milk, and the third spray-dried acidified skimmed milk. No vitamin or other supplement was given.

The 3 varieties of dried skimmed milk were high-quality products. They were manufactured by the usual processes,[4] but according to special directions. The production of the roller-dried milk was performed by one of the authors (S.G.W.). The dried milks were packed in tins, each of which contained approximately 26 lb., and stored at room temperature. Unfortunately, owing to a misunderstanding, the degree of acidity of the spray-dried acidified milk was only about 2% instead of the desired 4%. Lactic acid was therefore added at the rate of 1½ minims of 85% lactic acid per fl. oz. of the reconstituted formula, during the preparation of the feeds for the patients in this group.

Therapeutic Regimen

In the first 12-18 hours after admission, all patients received Hartman's solution with 5% dextrose by mouth, as well as 1-2 g. of potassium chloride, before the milk formulae were introduced. The fluid intake prescribed was approximately 2½ oz. per lb. body-weight per 24 hrs. The 3 dried milks were prepared so as to provide approximately 10 calories per fl. oz. but within a couple of days the feeds were strengthened to 15 calories per fl. oz. (1½ oz. of dried milk per 10 oz. of water). On admission, 1,200,000 units of benzathine penicillin G (Bicillin) were given intramuscularly, and sulphadiazine was given orally for 7 days at a dosage of 1½ gr. per lb. body-weight per day. Broad-spectrum antibiotics were prescribed in a few cases only; intravenous therapy with electrolyte solutions and/or plasma and blood was instituted when indicated.

Criteria of Successful Treatment

The term 'initiation of cure' is used here as previously defined by Brock *et al.*[6] Briefly, it can be said to have taken place when the patient's downhill course has been changed to an upward one. By this time, usually after from 12 to 21 days, rapid increases have taken place in the concentration of albumin in the serum and in the serum amylase activity and the patient has lost his oedema, has become interested in his surroundings, and has regained his appetite.

Analytical Methods

The methods used for the determination of serum proteins and serum amylase activity were identical with those prescribed previously.[7] Nitrogen in the food, faeces and urine was estimated in duplicate by a modification of the macro-Kjeldahl method.[8] The following methods were used for the analysis of the dried skimmed milks:

Moisture: A sample of 3 g. of dried milk was dried at 85-88°C for 6 hours or until constant in weight.[9]

Fat: The method described by Stodt[10] was used.

Total Solubility: The method used was that described in Richmond's Dairy Chemistry.[11]

Degree of Acidity: 4 g. of dried skimmed milk were dissolved in 32 ml. of water and the mixture titrated with N/9 NaOH (1 ml. of N/9 NaOH=0·1% lactic acid).

TABLE I. ANALYSIS OF THE DRIED SKIMMED MILKS

Type of skimmed milk powder	Pasteurisation of fresh milk	Organoleptic examination		Total Solubility %	Moisture	Fat %	Acidity		Protein % in solids	Lysine %	Vitamins mg. %			Analysis by Factory			
		Flavour and taste	Burnt particles and foreign matter				Lactic acid	pH in reconstituted milk			Thiamine	Riboflavin	Niacin	Moisture %	Fat %	Acidity of powder % lactic acid	Acidity of fresh milk % lactic acid
Acidified spray-dried skimmed milk	10 min. at 90°C	good	absent	100	3·6	2·0	1·95	6·5	33·8	4·1	·37	·66	·74	2·5	2·3	2·02	0·14
Spray-dried skimmed milk ..	10 min. at 90°C	good	absent	99	2·5	3·0	1·75	6·6	34·7	4·3	·46	·89	·79	2·2	2·6	1·66	0·14
Roller-dried skimmed milk ..	No pasteurisation	good	absent	85	5·4	3·4	2·10	6·45	36·4	4·2	·45	·73	1·31			1·68	0·18

pH-Value: This was determined by a potentiometric method.

Protein: A modification of the macro-Kjeldahl method[12] was used.

B-Vitamins: Determinations were made by modified methods as used by Hoffmann La Roche laboratories[13] and the Association of Vitamin Chemists.[14]

Balance Studies

Balance studies, based on the technique of Hansen,[7] were performed on 2 male patients in each group. The studies were commenced on the day after admission and separate collections of urine and faeces were made over a 3-day period. Carmine was used to mark the faeces.

RESULTS

The therapeutic effect of the 3 varieties of skimmed milk were assessed on the basis of their abilities to initiate cure and to increase the serum-albumin concentration and the serum amylase activity and in addition, in those cases where balance studies were carried out, on the basis of their effects on absorption and retention of nitrogen.

Analysis of the Skimmed Milks

The results of analysis of the 3 types of dried milk are shown in Table I. The well known difference in solubility between milks prepared by the two processes is clearly illustrated. The fat content was fairly high in all 2 samples analysed. The riboflavin contents of all 3 types of dried milk were remarkably low. There was no appreciable difference in lysine content between the 3 varieties of dried skimmed milk. This amino acid is liable to be damaged if overheating occurs during drum drying.[3]

Effects of Experimental Diets on Initiation of Cure

The results have been summarized in Table II according to a modification of the method described by Brock *et al.*[6] In this Table *group I* includes all cases where dietary treatment was successful and in which cure was fully initiated within 21 days; *group II* all cases in which additional supportive transfusion of plasma and blood was necessary to initiate cure; and *group III* all the cases which died. (No deaths occurred within 48 hours.)

TABLE II. SUMMARY OF CLINICAL RESULTS

Diet	No. of cases	Group I	Group II	Group III (Deaths)
Roller-dried skimmed milk ..	20	14	1	5
Spray-dried skimmed milk ..	20	17	1	2
Spray-dried acidified skimmed milk	20	14	3	3
Total ..	60	45	5	10

For the purpose of statistical analysis all cases not classed as a group-I cure were regarded as failures. A test of significance between the 2 percentages (14 and 17) $P_1=70\%$ $(14\div20\times100)$ and $P_2=85\%$ $(17\div20\times100)$, showed no significant difference. According to this analysis, therefore, no significant differences could be established between the 3 varieties of skimmed milk in initiating cure.

Effects of Diets on Serum Albumin Concentration and Serum Amylase Activity

In Tables III and IV are shown the average values, and the equations representing the regression lines, for rise of serum-albumin concentration and increase in serum amylase activity during treatment. Application of the t-test revealed no significant differences in the serum amylase activity between the 3 groups during the 3 weeks of treatment. On admission, the average values for serum albumin concentration of the 3 therapeutic groups did not differ significantly, but one or two weeks after admission the average value for the patients who received the spray-dried skimmed milk was significantly higher than the corresponding values for the other 2 groups. At the end of the third week, however, there were no significant differences between the values obtained for the 3 groups and it seems reasonable to conclude that the rise in serum albumin concentration was satisfactory in all 3 groups. The average values obtained for the patients who received roller-dried milk was almost identical with that for the group receiving spray-dried acidified milk.

TABLE III. INCREASE IN SERUM ALBUMIN CONCENTRATION DURING TREATMENT

Type of Skimmed Milk	Average values (g./100 ml)				Regression Lines*
	On admission	1st week	2nd week	3rd week	
Roller-dried	1·7	2·3	2·9	3·5	$Y=1\cdot72+0\cdot60\times$
Spray-dried	1·85	2·9	3·5	3·5	$Y=1\cdot80+1\cdot39\times-0\cdot28\times^2$
Spray-dried acidified	1·7	2·4	2·9	3·4	$Y=1\cdot75+0\cdot57\times$

* These equations represent regression lines of rise of serum albumin (Y) against time (X) during treatment with the three varieties of dried milk.

TABLE IV. INCREASE IN SERUM AMYLASE ACTIVITY DURING TREATMENT

Type of Skimmed Milk	*Average values (Somogyi units)*				*Regression Curves**
	On admission	*1st week*	*2nd week*	*3rd week*	
Roller-dried	62	117	128	147	$Y=62\cdot8+53\cdot79\times-9\cdot02\times^2$
Spray-dried	52	117	118	119	—
Spray-dried acidified	45	92	105	127	$Y=47\cdot27+44\cdot92\times-6\cdot36\times^2$

* These equations represent regression curves of rise in serum amylase activity (Y) against time (X) during treatment with the different varieties of skimmed milk. Due to a flattening of the curve at the 1st week, a parabola could not be fitted on the values obtained in the spray-dried group.

The Effect on Nitrogen Absorption and Retention

It can be seen from the data in Table V that the amounts of nitrogen retained were high in all 6 patients studied, in spite of the fact that an impairment in the absorption of nitrogen is usually found in acute kwashiorkor,[15-17] As, however, the number of patients studied was small, all that can be said is that nitrogen retention was satisfactorily high, irrespective of the variety of dried milk used.

TABLE V. NITROGEN BALANCE RESULTS

Case	*Diet*	*Weight (kg.)*	*Nitrogen Intake mg./kg./day*	*Urinary excretion of Nitrogen mg./kg./day*	*Faecal excretion of Nitrogen mg./kg./day*	*Total Nitrogen excretion mg./kg./day*	*Nitrogen retention mg./kg./day*	*% Nitrogen retention*	*% Nitrogen absorption*
1	Roller-dried skimmed milk	5·5	695	285	161	446	249	36	77
2	Roller-dried skimmed milk	7·8	726	181	87	268	458	63	88
3	Spray-dried skimmed milk	8·6	797	207	108	315	482	61	87
4	Spray-dried skimmed milk	8·0	523	48	81	129	394	75	85
5	Spray-dried acidified skimmed milk ..	8·0	490	92	132	244	266	54	73
6	Spray-dried acidified skimmed milk ..	10·3	658	187	114	301	357	54	83

SUMMARY AND CONCLUSIONS

Sixty Bantu infants admitted to hospital with kwashiorkor were divided in a random manner into 3 equal groups. During a period of 3 weeks one group was given a roller-dried skimmed milk, another group a spray-dried skimmed milk and the third group a spray-dried acidified skimmed milk.

No significant difference could be detected between the three therapeutic groups as regards initiation of cure or increase in serum amylase activity.

Initially there was a more rapid rise in the serum albumin content among the patients who received the spray-dried milk than among the remaining patients, but after 3 weeks no significant difference could be detected between the values obtained for the 3 groups. Nitrogen balance studies, performed on 2 male patients from each group, showed high retention of nitrogen in all cases.

The results therefore indicate that roller-dried skimmed milk of high quality which has been properly packed and stored can be as effective in initiating cure as spray-dried skimmed milk either with or without added lactic acid. This finding is of economic importance because drum-drying is cheaper than spray-drying.

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