

Clinical and biochemical assessment of a modified evaporated milk for infant feeding

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SUMMARY A clinical and biochemical evaluation has been made of a new milk formula, Modified Carnation milk (MCM), based on cows' milk but with the mineral content and concentration of caloric nutrients altered to make it correspond more closely to human milk. MCM produced higher plasma calcium and magnesium concentrations in 6-day-old infants than those produced by unmodified evaporated and dried milks, achieving concentrations closer to those of breast milk. Plasma free amino acid concentrations in MCM-fed infants are nearer breast-fed values than those in unmodified milk-fed infants where higher individual plasma amino acid concentrations persist during the first 3 months. MCM-fed infants had low plasma urea concentrations and lower urine osmolalities at 6 days, 3 weeks, 6 weeks, 3 months, and 6 months than infants fed on the evaporated and dried milks, and similar plasma urea and urine osmolalities to those of breast-fed infants.

MCM is likely to be superior to unmodified evaporated and dried milks in preventing convulsions of the hypocalcaemic/hypomagnesaemic/hyperphosphataemic type, and seems less likely to cause hypertonic dehydration. MCM is easily prepared, readily accepted by babies, and appears to be nutritionally adequate for the feeding of term infants.

A recent report recommends that mothers should breast feed their babies for a minimum of 2 weeks and preferably for the first 4 to 6 months of life (Department of Health and Social Security, 1974). Cows' milk, usually modified (Gerstenberger and Ruth, 1919), has long been used as a substitute for breast milk but recently there has been a tendency to make milk-based formulae resemble human milk more closely in terms of nutritional composition in the belief that this is better for the growing infant. Because of considerable evidence that existing infant formulae based on cows' milk provoke neonatal tetany, with hypocalcaemia, hyperphosphataemia, and hypomagnesaemia (Bakwin, 1937; Gittleman and Pincus, 1951; Oppé and Redstone, 1968; Cockburn *et al.*, 1973) and/or hypernatraemic dehydration (Taitz and Byers, 1972; Oates, 1973; Davies, 1973; Shaw *et al.*, 1973) the main modifications in manufacture have been to reduce the total solute load of the formula, usually by reducing the protein and mineral contents.

In this study, comparison has been made between groups of newborn infants fed:

- (i) breast milk (BM),
- (ii) modified evaporated

milk 'Carnation', a new milk-based infant formula (MCM), (iii) standard evaporated milk 'Carnation' (SCM), and (iv) full-cream dried milk, 'Ostermilk No. 2' (OM2). The new modified Carnation milk differs from the other formulae in that the mineral content and concentration of caloric nutrients in fresh cows' milk have been altered to conform more closely to values found in human milk by the addition of a vegetable oil mixture (corn oil and coconut oil) and a carbohydrate solution containing glucose solids. The compositions of the three artificial milk formulae and breast milk are compared in Table 1.

Patients and methods

Infants from three wards in the Maternity Hospital were fed from birth on MCM, SCM, and OM2 respectively, one type of feed only being used on each ward. Mothers wishing to breast feed were encouraged to do so. During the first few days after the birth of their baby, mothers were informed about the study and those who consented to take part were thus already in one of the four groups. 101 patients, all Caucasian, effectively participated.

A heel-prick blood sample was taken at the same

Table 1 *Composition of infant formulae (per 100 ml)*

	<i>Breast milk</i>	<i>Ostermilk No. 2</i>	<i>Modified Carnation</i>	<i>Standard Carnation</i>
Calories, kcal (kJ)	67 (280)	69* (288)	68 (284)	67* (280)
Protein (g)	1.3	3.3	1.9	2.7
Fat (g)	3.7	3.3	3.7	2.9
Carbohydrate (g)	7.3	6.7*	7.0†	7.6*
<i>Minerals</i>				
Calcium (mg)	35	114	64	95
Phosphorus (mg)	14	91	52	83
Magnesium (mg)	3.0	12.3	8.8	11.6
Sodium (mg)	20	56	32	50
Potassium (mg)	62	138	73	133
<i>Fatty acids (as a % of total)</i>				
Saturated	53	64	52	65
C10.0 (capric)	1.3	2.5	2.5	2.7
C12.0 (lauric)	5.6	2.7	8.4	2.6
C14.0 (myristic)	7.6	11.0	8.1	9.6
C16.0 (palmitic)	27.1	28.2	19.0	23.4
C18.0 (stearic)	9.3	13.8	6.9	9.7
Unsaturated	47	36	48	35
Monounsaturated	39	34	28	33
C16.1 palmitoleic	4.2	2.6	1.1	2.2
C18.1 oleic	34.3	31.7	26.1	28.6
Polyunsaturated	8	2	20	2
C18.2 linoleic	7.2	1.8	19.8	1.8
C18.3 linolenic	0.7	Trace	Trace	—

*Includes sucrose added in preparation when the milk is made up according to manufacturer's instructions.

†Lactose 2.7 g, glucose solids 4.3 g (principally disaccharides and higher saccharides).

time as the Guthrie test sample on the sixth day of life and a urine sample was collected on the sixth day. Crown-rump length, occipitofrontal head circumference, and skinfold thickness in the triceps, subscapular and supriliac regions were measured on the first and sixth days of life. Skinfold thickness was measured by the method of Tanner (1973) using Holtain skinfold calipers. Mothers and their infants were seen again at 3 weeks, 6 weeks, 3 months, and 6 months of age. Blood (heel prick) and urine samples were collected at each of these times and the anthropometric measurements repeated. On all blood samples total protein, sodium, potassium, calcium, magnesium, phosphorus, haemoglobin, and haematocrit were estimated but because of the small amounts of blood available plasma urea was estimated only on 6-day and 3-month samples, plasma glucose on 6-day samples, total plasma lipids on 6-week and 6-month samples, and both plasma cholesterol and nonesterified fatty acids on 6-day, 6-week, and 6-month samples. Concentrations of plasma-free amino acids and urea were measured in pooled specimens from all blood samples in each of the four groups (20 μ l plasma from 10 infants; and stored at -70° C until analysed). Plasma osmolality was measured on some 6-day samples, and urine osmolality on all the urine samples.

Ca, Mg, Na, and K were estimated by atomic absorption spectrophotometry using a Unicam SP 90 spectrophotometer (Unicam instruction sheets Ca1, Mg1, Na1, K2); total protein by an ultramicro adaptation of the methods of Kingsley (1939) and Gornall *et al.* (1949) using a modified biuret reagent; phosphorus by a micromethod based on the method of Fiske and Subbarow (1925); urea by a urease catalysis and phenol/hypochlorite reaction method based on that of Fawcett and Scott (1960). Total plasma lipids were estimated using a Boehringer method based on the procedure of Zöllner and Kirsch (1962); cholesterol by the method of Jamieson (1964) and nonesterified fatty acids by the method of Novak (1965); plasma glucose by the glucose oxidase technique (Raabo and Terkildsen, 1960); and microhaematocrit and haemoglobin in the standard way. Osmolality was measured with the Advanced Instruments Osmometer, type 3LAS or 3W, and plasma amino acids by column chromatography (Cockburn *et al.*, 1971).

Results

Biochemical aspects.

Plasma calcium (Table 2). BM-fed infants had a higher mean plasma Ca at 6 days (2.55 mmol/l;

Table 2 Plasma and urine biochemical values for infants fed four different milks: breast milk (BM), Ostermilk 2 (OM2), modified Carnation (MCM), and Carnation (SCM)

Age	6 days	3 weeks	6 weeks	3 months	6 months
<i>Plasma calcium (mmol/l)</i>					
BM	31* 2.55±0.23	24* 2.65±0.30	16* 2.70±0.21	15* 2.78±0.28	14* 2.73±0.19
OM2	22 2.20±0.40	19 2.60±0.32	20 2.62±0.31	17 2.94±0.22	18 2.78±0.28
MCM	24 2.37±0.36	19 2.53±0.30	22 2.71±0.26	17 2.82±0.19	15 2.85±0.29
SCM	22 2.14±0.32	23 2.63±0.36	22 2.71±0.26	21 2.79±0.23	21 2.73±0.17
<i>Plasma phosphorus (mmol/l)</i>					
BM	31 2.02±0.37	24 2.26±0.37	16 2.14±0.21	15 2.00±0.17	12 2.10±0.39
OM2	21 2.85±0.61	18 2.47±0.30	20 2.47±0.25	18 2.39±0.22	17 2.06±0.27
MCM	24 2.60±0.30	19 2.36±0.24	22 2.37±0.23	21 2.30±0.28	17 2.08±0.26
SCM	22 2.60±0.36	24 2.30±0.24	23 2.25±0.22	22 2.33±0.21	21 2.16±0.22
<i>Plasma magnesium (mmol/l)</i>					
BM	31 0.83±0.09	24 0.84±0.09	16 0.88±0.08	15 0.98±0.09	14 0.98±0.06
OM2	22 0.74±0.11	19 0.86±0.09	20 0.89±0.11	17 0.95±0.08	18 0.98±0.10
MCM	24 0.83±0.10	19 0.93±0.08	22 0.90±0.11	21 0.95±0.10	15 0.96±0.09
SCM	22 0.75±0.08	23 0.84±0.11	22 0.91±0.08	21 0.92±0.09	21 0.91±0.11
<i>Plasma sodium (mmol/l)</i>					
BM	28 133±7	17 137±9	16 137±11	15 136±9	11 137±9
OM2	20 136±16	18 142±12	19 140±15	19 140±12	13 138±11
MCM	18 133±9	14 134±8	19 131±7	20 133±12	12 136±12
SCM	22 138±19	20 134±13	21 131±10	20 131±13	17 139±10
<i>Total plasma proteins (g/l)</i>					
BM	31 66.0±5.6	21 70.3±10.2	15 66.7±7.8	13 73.4±9.1	13 69.2±11.1
OM2	19 60.5±8.1	14 57.8±6.1	15 64.8±6.8	14 66.2±6.0	18 67.7±5.9
MCM	23 63.6±7.1	18 66.6±6.9	21 66.0±6.1	20 62.6±6.1	18 68.3±8.8
SCM	18 68.3±8.0	20 65.8±7.6	18 65.2±5.9	18 64.5±6.2	19 69.0±7.8
<i>Urine osmolality (mOsm/kg)</i>					
BM	23 98±55	10 110±42	11 123±73	9 89±37	2 268±200
OM2	16 281±102	12 343±156	7 311±158	5 458±207	8 481±228
MCM	16 119±60	8 137±60	6 140±52	9 208±35	9 366±188
SCM	18 176±65	12 361±43	10 314±122	9 454±195	9 507±253

* The number of samples is given, followed by the mean ±SD.

Conversion: SI to traditional units—Calcium: 1 mmol/l ≈ 4 mg/100 ml. Phosphorus: 1 mmol/l ≈ 3.1 mg/100 ml. Magnesium: 1 mmol/l ≈ 2.4 mg/100 ml. Sodium: 1 mmol/l ≈ 1 mEq/l.

10.2 mg/100 ml) than infants on any of the other three milks ($P < 0.01$). However at 6 days Ca in infants fed with MCM (2.37 mmol/l; 9.5 mg/100 ml) was higher ($P < 0.05$) than with SCM (2.14 mmol/l; 8.6 mg/100 ml), and higher, but not significantly so, than with OM2 (2.20 mmol/l; 8.8 mg/100 ml). From 3 weeks onwards there was very little difference between any of the milks.

Plasma phosphorus (Table 2). Mean plasma P with BM (2.02 mmol/l; 6.3 mg/100 ml) was lower ($P < 0.01$) at 6 days than with all other milks (SCM 2.60 mmol/l, 8.1 mg/100 ml; MCM 2.60 mmol/l, 8.1 mg/100 ml; OM2 2.85 mmol/l, 8.9 mg/100 ml). It was also significantly lower than with MCM at 6 weeks (2.14/2.37 mmol/l; 6.7/7.4 mg/100 ml) and 3 months (2.00/2.30 mmol/l; 6.3/7.2 mg/100 ml); SCM at 3 months (2.00/2.33 mmol/l; 6.3/7.3 mg/100 ml); and OM2 at 3 weeks (2.26/2.47 mmol/l; 7.1/7.7 mg/100 ml), 6 weeks (2.14/2.47 mmol/l; 6.7/7.7 mg/100 ml), and 3 months (2.00/2.39 mmol/l; 6.3/7.4 mg/100 ml).

Plasma magnesium (Table 2). BM-fed infants (0.83 mmol/l; 2.02 mg/100 ml) and infants fed on MCM (0.83 mmol/l; 2 mg/100 ml) had higher mean plasma Mg values at 6 days than infants fed on SCM (0.75 mmol/l; 1.83 mg/100 ml) and OM2 (0.74 mmol/l; 1.81 mg/100 ml) ($P < 0.02$ in all cases). At 3 weeks Mg was still higher with MCM (0.93 mmol/l; 2.26 mg/100 ml) than with SCM (0.84 mmol/l; 2.04 mg/100 ml; $P < 0.05$) and OM2 (0.86 mmol/l, 2.10 mg/100 ml; $P < 0.01$).

Plasma sodium (Table 2). MCM produced mean Na concentrations similar to those in BM-fed infants. The mean (\pm SD) with OM2 (142±12 mmol/l; 142±12 mEq/l) was higher than with MCM (134±8, $P < 0.05$) at 3 weeks, and higher than with SCM at 3 weeks ($P < 0.01$), 6 weeks ($P < 0.01$), and 3 months ($P < 0.05$). Hypernatraemia was seen in all groups; 4 out of 87 (5%) plasma sodiums in the BM, 6 out of 89 (7%) in the OM2, 4 out of 83 (5%) in the MCM, and 5 out of 100 (5%) in the SCM groups were 155 mmol/l or greater.

Plasma potassium. Mean plasma potassium concentrations with OM2 tended to be higher than with the other three milks, though no significant differences were present at 6 days of age. Values with BM (5.2 ± 0.4 mmol/l; 5.2 ± 0.4 mEq/l) were lower than with OM2 (5.9 ± 0.2) at 6 weeks and 3 months ($5.1 \pm 0.5/5.6 \pm 0.6$) ($P < 0.01$ in both instances), and lower than with MCM (5.6 ± 0.7) at 6 weeks ($P < 0.05$); those with MCM (5.1 ± 0.5) were lower than with OM2 (5.6 ± 0.6) at 3 months ($P < 0.01$); those with SCM (5.5 ± 0.5) lower than OM2 (5.9 ± 0.2) at 6 weeks ($P < 0.01$) and 3 months ($5.2 \pm 0.6/5.6 \pm 0.6$, $P < 0.05$).

Total plasma proteins (Table 2). The mean total plasma protein value in BM-fed infants was higher than in other groups. It was higher than in the OM2 group at 6 days ($66.0/60.5$ g/l; $P < 0.01$) and 3

weeks ($70.3/57.8$, $P < 0.01$), and higher than in the MCM and SCM groups at 3 months ($73.4/62.6$, $P < 0.01$; and $73.4/64.5$, $P < 0.01$). The mean in the MCM group was higher than in the OM2 group at 3 weeks ($66.6/57.8$, $P < 0.02$), but lower at 3 months ($62.6/66.2$, $P < 0.01$). The SCM mean value at 6 days (68.3) was higher ($P < 0.01$) than that of the OM2 group (60.5).

Plasma amino acids (Fig. 1). Fig. 1 shows plasma-free amino acid concentrations in the three groups of infants fed cows' milk formulae as a percentage of the values found in the plasma of breast-fed infants. It can be seen that plasma amino acid concentrations in modified Carnation-fed infants were nearer breast-fed values than the unmodified milks, but throughout the first 3 months plasma concentrations were greater in all three artificially-fed groups. At

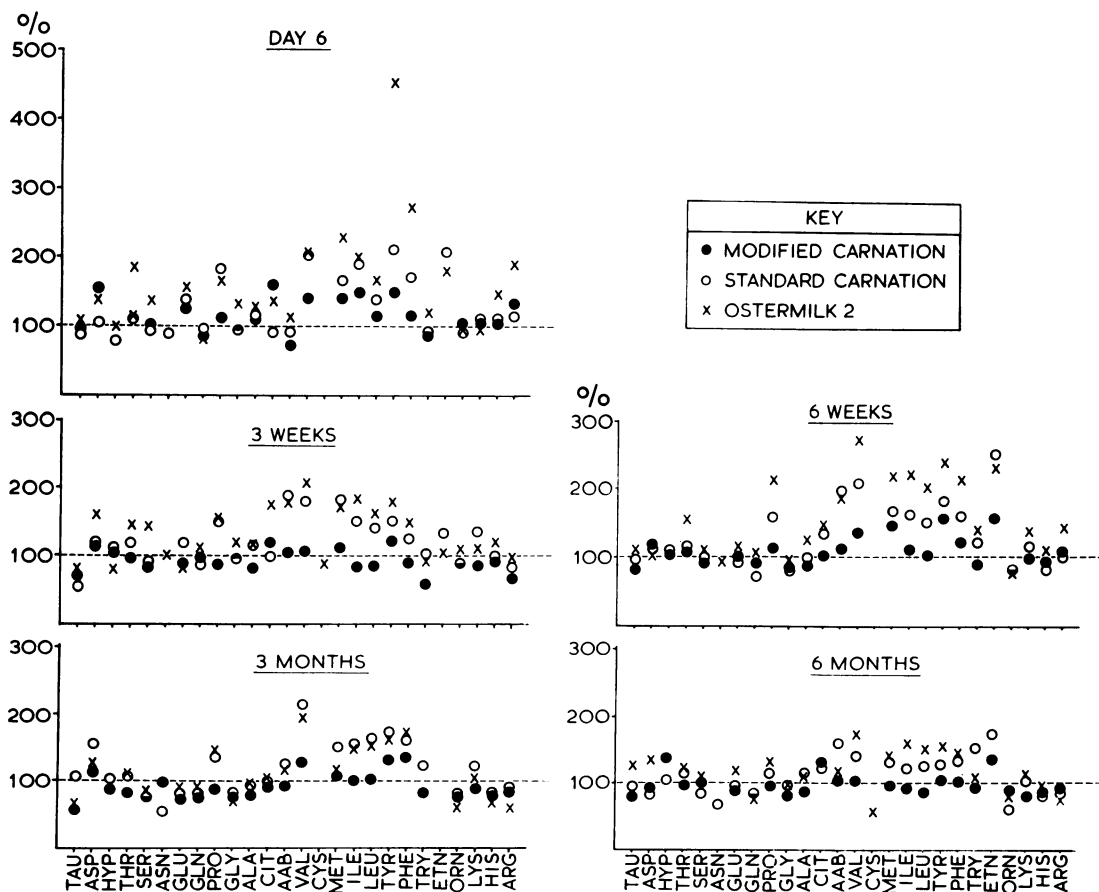


Fig. 1 Mean plasma amino acid concentrations in the first 6 months in three groups of infants fed different milks, expressed as a percentage of the mean values measured in a fourth group of breast-fed infants.

day 6 there were already particularly high plasma concentrations of valine, methionine, tyrosine, phenylalanine, and ethanolamine in infants fed unmodified milks. Total free amino acid concentrations in infants fed SCM and OM2 were maintained between 1½ to 2 times that in breast-fed infants throughout the first 3 months and this was reflected in plasma urea concentrations (Table 4).

Plasma urea (Fig. 2, Table 3), **urine osmolality** (Table 2), and **plasma osmolality** (Table 4). Groups which had lower mean plasma urea also had lower urine osmolality values. Fig. 2 shows that urea values for infants fed BM (3.20 ± 0.97 mmol/l, 19.2 ± 5.8 mg/100 ml; and 3.72 ± 2.29 mmol/l, 22.3 ± 13.8 mg/100 ml) and MCM (3.05 ± 0.88 mmol/l, 18.3 ± 5.3 mg/100 ml; and 3.88 ± 0.90 mmol/l, 23.3 ± 5.4 mg/100 ml) were lower than for OM2 (6.22 ± 2.00 mmol/l, 37.3 ± 12.0 mg/100 ml; and 6.84 ± 1.26 mmol/l, 41.2 ± 7.6 mg/100 ml) and SCM (5.08 ± 1.50 mmol/l, 30.5 ± 9.0 mg/100 ml; and 7.15 ± 1.21 mmol/l, 43.1 ± 7.3 mg/100 ml) infants at both 6 days and 3 months ($P < 0.01$ in all). Table 3 shows plasma urea concentrations obtained from the amino acid chromatographs and indicates

that at all ages the plasma urea levels in BM and MCM infants were much lower than in infants on SCM and OM2.

Table 2 shows a similar position for urine osmolality values. The BM and MCM groups had significantly lower osmolalities than the OM2 and SCM groups up to 3 months ($P < 0.01$ in all, except $P < 0.05$ for MCM/OM2 at 6 weeks).

Despite these marked differences in plasma urea and urine osmolality there were no significant differences between the groups with respect to plasma osmolality at 6 days of age (Table 4). The

Table 4 Plasma osmolality concentrations (mOsm/kg) at 6 days of age

Group	No.	Mean ± SD
BM	9	292 ± 9
OM2	12	290 ± 6
MCM	11	293 ± 9
SCM	11	288 ± 6

mean values of the latter were all in the normal range although 5 of the 43 estimations were over 300 mOsm/kg.

Table 3 Plasma urea concentrations (mmol/l)

	6 days	3 weeks	6 weeks	3 months	6 months
BM	1.9	3.3	2.5	2.7	3.2
OM2	8.6	11.9	8.6	8.4	5.9
MCM	2.2	2.2	3.0	3.5	4.6
SCM	6.5	8.7	14.2	10.4	9.1

Conversion: SI to traditional units—Urea: 1 mmol/l ≈ 6 mg/100 ml.

Haematocrit and haemoglobin. No significant differences were found between any of the groups at 6 days, 3 weeks, 6 weeks, and 3 months. At 6 months of age, the mean haematocrit of MCM-fed infants ($37.3\% \pm 2.2$) was similar to that of BM-fed (38.1 ± 4.1) but lower than that of OM2 fed (40.4 ± 2.4) and SCM fed (39.6 ± 2.6) ($P < 0.01$ in

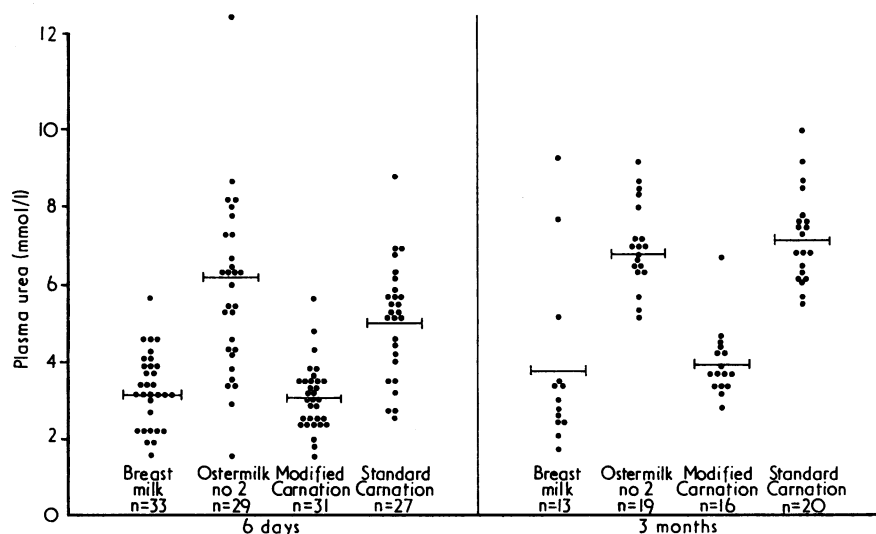


Fig. 2 Plasma urea in infants Conversion: SI to traditional units—Plasma urea: 1 mmol/l ≈ 6 mg/100 ml.

both cases). All groups showed the usual postnatal falls in haematocrit and Hb.

Plasma glucose. No differences were evident in plasma glucose values at 6 days. Though samples were taken just before the same morning feed there was wide variation in individual values.

Lipids. (Total plasma lipids, plasma cholesterol, and plasma nonesterified fatty acids.) There were few differences between the groups. OM2 resulted in lower plasma nonesterified fatty acids at 6 days than BM ($P < 0.02$) and MCM ($P < 0.05$), and lower cholesterol at 6 weeks than SCM ($P < 0.01$).

Growth measurements.

Weight. No significant differences in absolute weight were found between any of the groups, but during the first 6 months of life all artificially-fed babies showed a weight gain significantly greater than that of BM-fed infants. With MCM this increased weight gain was seen at 6 days ($P < 0.01$) and 3 weeks ($P < 0.02$), with OM2 and SCM at 6 days ($P < 0.01$) and 6 months ($P < 0.02$). When weight gain data for the groups were divided by sex, males showed 10 significant differences and females 2.

Crown-rump length. At 3 weeks female infants fed on BM and MCM were longer than those fed on OM2 ($P < 0.05$) and the MCM-fed infants showed a greater gain in crown-rump length from birth than OM2-fed infants ($P < 0.05$).

Head circumference (OFC). Of 8 significant differences relating to OFC measurements, 5 were at 6 months of age. BM and MCM infants had a greater OFC at 3 and 6 months than OM2-fed infants ($P < 0.02$ BM/OM2; $P < 0.05$ MCM/OM2), and SCM-fed infants had a greater OFC at 6 months than OM2 ($P < 0.05$). BM-fed infants had a greater increase in OFC than SCM-fed at 3 weeks ($P < 0.02$) and OM2-fed at 3 months ($P < 0.01$). MCM-fed infants showed similar increases to BM-fed infants at 3 months and these were greater than those of OM2 infants ($P < 0.05$).

Skinfold thicknesses.

Triceps measurements showed greater skinfold thicknesses in MCM- and SCM-fed infants compared with BM-fed infants. *Subscapular* measurements showed generally greater values for MCM-fed infants compared with BM- and SCM-fed fed infants. Similarly, in 13 out of 16 significantly different *suprailiac* measurements, MCM-fed infants showed greater skinfold thickness than the infants in the other 3 groups.

Discussion

There are no absolute guidelines for assessing the quality of a new milk formula. The main aim must be to ensure that the new product is well tolerated, results in 'optimal' growth, and produces no undesirable effects such as gastrointestinal disturbance, allergy, and convulsions, and no significant disturbance of metabolism. Clinical, biochemical, and haematological assessments must be made over a reasonable period of time but the yardsticks which can be applied are limited. Complete evaluation before general usage is impossible.

The new infant formula (MCM), which is the subject of this study, derives from the concept that the composition of artificial milks for human infants should be as near as possible to that of human milk. Replication is not possible, only compromise modifications. The mineral, solute, and protein concentrations and the source of calories in cows' milk have been altered by diluting cows' milk by adding a vegetable oil mixture (corn oil and coconut oil) and carbohydrates (glucose solids). Thus, compared with a representative evaporated milk (SCM), the protein content has been reduced from 27 to 19 g/l, the fat content increased from 29 to 37 g/l, and the carbohydrate content reduced from 92 to 70 g/l. The content of Na, K, Ca, P, and Mg has been reduced and the Ca:P ratio marginally increased from 1.14 to 1.23 (compared with a ratio of 2.3 for transitional human breast milk and 2.4 for mature breast milk found by Macy, 1949; 1.85 and 2.43 by Widdowson, 1965; 1.8 and 2.3 by Davidson, 1968; 1.4 and 1.7 by Hanna *et al.*, 1970; and 2.0 and 1.8 by Barltrop and Hillier, 1974). Barltrop and Hillier suggest that milk Ca:P ratios are of less significance for neonatal calcium homeostasis if the total mineral load is low, as is the case with MCM.

The most marked biochemical effects of MCM compared with a representative evaporated milk (SCM) and a dried milk powder (OM2) are in relation to plasma Ca, P, Mg, amino acids, and urea concentrations, and to urinary osmolality. One of the aims of the new formulation was to reduce P concentration so that neonatal tetany would be less likely to occur. No cases of neonatal tetany were observed in the group of infants, admittedly small, who received MCM. Neonatal tetany has its peak incidence on the sixth day of life (Brown, *et al.*, 1972). Its pathogenesis is not yet completely resolved. Vitamin D deficiency in the mother during pregnancy is probably a primary cause (Watney *et al.*, 1971; Purvis *et al.*, 1973; Watney and Rudd, 1974; Belton *et al.*, 1975) but fetal parathyroid hypoplasia as a result of increased circulating maternal

parathyroid hormone may be a direct cause of hypocalcaemia in the infant (Bakwin, 1937; Albright and Reifenstein, 1948; Lequin *et al.*, 1970; Cushard *et al.*, 1972). Phosphate loading aggravates the hypocalcaemia of hypoparathyroidism (even in the presence of concomitant calcium loading), hence reduction of phosphate intake is likely to reduce the risk of tetany. MCM feeding did not reduce the plasma P or raise Ca to the concentrations found in breast-fed infants at day 6, but resulted in a Ca:P ratio on day 6 nearer to that for BM and higher than that for SCM and OM2 (i.e. BM 1.33 ± 0.29 , MCM 0.93 ± 0.16 , SCM 0.87 ± 0.21 , and OM2 0.81 ± 0.23). The Ca:P ratio for BM was greater than those for the other three groups ($P < 0.01$) and that for MCM was greater than that for OM2 ($P < 0.05$). Serum immunoreactive calcitonin is high in newborn infants (Samaan *et al.*, 1974, 1975) and may make them more sensitive to parathyroid deficiency and phosphorus loading.

Hypomagnesaemia is frequently a factor in neonatal tetany (Tsang, 1972; Cockburn, *et al.*, 1973) and various factors such as a high phosphate load (Anast, 1964; Coussons, 1969), impaired magnesium absorption (Paunier *et al.*, 1965; Salet *et al.*, 1966), target unresponsiveness (Seelig, 1971), and transitory functional hypoparathyroidism (Davis *et al.*, 1965) appear to contribute to it. Neonatal hypocalcaemia may respond to magnesium but not to calcium (Paunier *et al.*, 1965; Davis *et al.*, 1965; Salet *et al.*, 1966), and Turner *et al.* (1975) have shown that intramuscular magnesium sulphate is a more rapid and effective treatment of an established case of neonatal hypocalcaemia than either oral calcium gluconate or oral phenobarbitone. Thus a milk which results in higher magnesium concentrations in the infant is likely to reduce the risk of neonatal tetany. MCM achieved a mean plasma Mg similar to that in BM-fed infants at 6 days and an even higher concentration at 3 weeks.

Hypernatraemia was not a problem in infants fed on MCM and its low protein, mineral, and solute content compared with the SCM and OM2 is reflected in the very clear differences between the groups in the serum urea and urinary osmolality results. MCM compared favourably with breast milk and is likely to confer considerable protection on infants against hypertonic dehydration and hyper-electrolytaemia. High plasma free amino acid concentrations found in infants fed unmodified milks probably reflects the higher protein intake. There is as yet no evidence of benefit or harm from persistently high plasma amino acid values. Davies and Saunders (1973) and Dale *et al.* (1975) found higher blood urea values in infants aged 1 to 3

months fed on artificial milk compared with breast milk. Reduction in solute load therefore appears to be an important and beneficial property of MCM. As MCM is supplied in the form of liquid evaporated milk there is likely to be less error in its reconstitution (normal dilution is 1:1) than in the reconstitution of dried milk powder where the risks of serious error have been well documented (Taitz and Byers, 1972; Wilkinson *et al.*, 1973).

As judged on height, weight, head circumference, and skinfold thickness, MCM seems to be entirely adequate nutritionally. In common with the other two artificial milks it tends to result in infants of greater weight than those fed on breast milk, whereas the breast-fed infants and those fed MCM showed some tendency to be longer than infants given OM2. There is a greater awareness now of the risks of obesity in babies, but this is considered to be due to excessive and too early feeding with carbohydrate. It could be argued that the performance of MCM in terms of weight and length might be an argument to convince mothers that infants can develop and grow adequately on a modified cows' milk of appropriate type without additional carbohydrate until at least 4 to 6 months of age. The greater head circumference found in infants fed MCM and BM, compared with SCM and OM2, raises interesting speculations regarding brain development with different feeds.

The linoleic acid of MCM (19.8% of the fatty acids) is considerably higher than that of other milks including that of most breast milk. However, studies have shown that the linoleic acid content of breast milk varies with the mother's diet and a mean value as high as 15.2% was reported in a group of Jordanian mothers (Read *et al.*, 1965). Studies by Widdowson *et al.* (1974) on the composition of milks on sale in seven European countries showed that 16 of the 18 milks analysed had a linoleic acid content greater than 10% and that 2 had a content of over 40%. Widdowson *et al.* (1975) have subsequently shown that triglycerides in the adipose tissue of infants reflect the fatty acid profile of the fat in the diet. Such evidence makes it extremely difficult to decide on the nature and concentration of constituents of a milk for infant feeding.

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