VEGETABLE OIL FORTIFIED FEEDS IN THE NUTRITION OF VERY LOW BIRTHWEIGHT BABIES

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ABSTRACT

Two kinds of oils (i) Polyunsaturated fatty acids (PUFA) rich Safflower oil, and (ii) Medium chain triglyceride (MCT) rich Coconut oil were added to the feeds of 46 very low birthweight (VLBW) babies to see if such a supplementation is capable of enhancing their weight gain. Twenty two well matched babies who received no fortification served as controls. The oil fortification raised the energy density of the feeds from approximately 67 kcal/dl to 79 kcal/dl. Feed volumes were restricted to a maximum of 200 ml/kg/day.

The mean weight gain was highest and significantly higher than the controls in the Coconut oil group (19.47±8.67 g/day or 13.91 g/day). Increase in the triceps skinfold thickness and serum triglycerides were also correspondingly higher in this group. The lead in the weight gain in this group continued in the follow up period (corrected age 3 months). As against this, higher weight gain in Safflower oil group (13.26±6.58 g/day) as compared to the controls (11.59±5.33 g/day), failed to reach statistically significant proportions, probably because of increased statistically significant proportions, probably because of increased steatorrhea (stool fat 4+ in 50% of the samples tested). The differences in the two oil groups are presumably because of better absorption of MCT rich coconut oil. However, individual variations in weight gain amongst the babies were wide so that some control babies had higher growth rates than oil fortified ones. The technique of oil fortification is fraught with dangers of intolerance, contamination and aspiration. Long term effects of such supplementation are largely unknown. Hence, such fortification should be used in selected situations only, rather than as a routine nursery policy.

Key words: *Oil fortified feeds, Neonatal nutrition.*

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The prematurely born baby is unique, being neither a normal fetus nor a normal full term infant. Adequate nutrition of such a baby constitutes a formidable challenge with high energy demands(1) on the one hand and gastrointestinal immaturity(2) on the other. In our country, these problems are further compounded by intrauterine malnutrition which affects up to 50% of the preterms(3).

Although, the use of parenteral nutrition in small preterms has dramatically improved their survival(4), the technique is not free from complications, it is expensive and available only at a few centres. Development of suitable enteral feeds, therefore, becomes mandatory. Anti-infective and other properties(5), perhaps make the preterm mother's milk ideal for their own baby. But, growth and accretion studies in preterms have expressed concern about the quantitative and qualitative adequacy of breast milk alone(6-8) and various fortifications have been suggested with a view to increaseed the caloric density(9,10). Protein supplementation is fraught with risk of plasma hyperosmolarity(1,11) while physiologically low disaccharidase levels restrict the use of sugars(10). However, the low osmolar load of fats make fortification with oils especially promising(1,9,10).

We have studied the use of two freely available household cooking oils for fortification of breast milk: (*i*) predominantly long chain polyunsaturated fatty acid (PUFA) oil with abundance of essential fatty acids 'Safflower oil' (PUFA content 92%)(13), and (*ii*) the medium chain triglyceride (MCT) abundant but essentially saturated coconut oil (MCT content 67.3-89.5%). The specific questions asked were whether oil fortification is safe, is it capable of inducing higher and adequate growth rates and which oil served the purpose better.

Material and Methods

During a period of 12 months, 75 very low birthweight (VLBW) babies from the Neonatal Unit of KEM Hospital were enrolled for the study. Informed consent was obtained from all. The criteria for enrolment were (*a*) birthweight between 1250-1500 g, (*b*) postnatal age less than 2 weeks, and (*c*) establishment of enteral feeding. Babies with surgical problems, congenital anomalies and gastrointestinal disorders were excluded.

Feeding Protocol

As far as possible, mother's own milk was used for feeding, failing which, pooled expressed breast milk (EBM) or a standard 'Humanized' proprietary formula (Dexolac, Wockhardt Ltd.,) were used. Feed volumes were increased as per tolerance up to a maximum of 200 ml/kg/day. Nasogastric (NGT) feeds were given every 2 hours. Breast feeding was initiated and encouraged on development of appropriate reflexes with gradual withdrawal of NGT feeding.

On enrolment for study, babies were randomly allocated to one of the 3 following groups:

(*i*) Oil fortification PUFA-predominant–Safflower oil ('Safola', Marico Industries Ltd., Bombay).

(*ii*) Oil fortification with MCT predominant–Coconut oil ('Parachute', Marico Industries Ltd., Bombay).

(*iii*) Controls with no fortification.

Fortification of feeds with oil was done in the nursery by delivering the calculated amount directly into the nasogastric tube by special drop bottles and then flushing it down with the feeds. Calculations of fortification were made to increase the energy density of the feeds from 67 kcal/dl to 79 kcal/dl (addition of 2 drops per 5 ml feed, 1 drop = 30 mg). The energy density, total fat intake, fat as per cent of total energy, essential fatty acid content and MCT content of fortified milks as compared to European Society of Pediatric Gastroenterology and Nutrition (ESPGAN) Committee recommendations(4) is shown in *Table I.*

Addition of oil to feeds was discontinued temporarily on signs of intolerance. Intravenous fluids were given whenever indicated and accounted for in the caloric counts.

Monitoring

While in the nursery, the babies were monitored for:

(*i*) Clinical symptoms such as flatulence, abdominal distention, vomiting and diarrhea.

TABLE I—*Characteristics of Preterm Human Breast Milk and Fat-Fortified Milks in Relation to Recommendations of the Espgan Committee(14).*

Characteristics	Units	Espgan 1987	Human preterm milk (15)	Milk fortified with Safflower oil*	Milk fortified with Coconut oil*
Energy density	kcal/dl	65-85	67-70	79.00	79.00
Maximal fat intake per day at feed volume 200 ml/day	g/kg/day	4-9	8	9.40	9.40
Fat density	g/100/kcal	3.6-7.0	5.7	5.94	5.94
Fat (per cent of total energy)	%	40-50	40-50	56.40	56.40
MCT (per cent of total fat)	%	<40	35	36.50	43-49
Linoleic acid content	g/100/kcal	>0.5	0.4-0.7	1.08-1.38	0.41-0.73

* Characteristics of oil-fortified milks have been extrapolated as per composition of these oils(13).

(*ii*) Stools were examined daily for fat by semiquantitative method of Davidson and Henry(18).

(*iii*) Serum triglyceride levels were estimated:

(*a*) Prior to initiation of enteral feeding, and

(*b*) 7 days after enrolment to the study (prefeed sample), that is after establishment of feeding schedule.

Estimation was done on an Antoanalyzer using chemical reagents (Abbott Laboratories, U.S.A.).

(*iv*) Growth was monitored by:

(*a*) Daily weight on an electronic digital scale (Accuracy +5g), and

(*b*) Skinfold thickness (triceps) measured every week by Lange Skinfold caliper (Cambridge, Maryland).

Babies were discharged from the nursery on establishment of oral such feeds and demonstration of weight gain irrespective of weight or postnatal age achieved. They were followed up regularly at a special High Risk Clinic or by home-visits, where further growth, mortality and morbidity were monitored.

Analysis

All data was fed an IBM PC/XT computer and analysed using specially designed software programmes and standard tests of significance.

Results

Of the 75 babies enrolled, 4 died early in the course of the study (2 of the safflower oil group and 1 each of the coconut oil and control groups), and 1 developed necrotizing enterocolitis soon after enrolment to study. These 5 babies were excluded from further analysis. The number of babies who completed the study in the various groups were: (*i*) Safflower oil fortification group–22, (*ii*) Coconut oil fortification group–24, and (*iii*) Controls (No fortification)–24.

Clinical Features

The clinical profile (birthweight, gestational age and associated conditions) was similar in all the groups (*Table II*). Age of enrolment and period of study were also similar.

Three babies of the safflower oil group and 2 each of the other two groups developed loose motions on the study. The diarrhea in the Safflower oil group was related to oil addition exceeding 0.5ml (23 drops per feed) and responded to discontinuation of oil. In the coconut oil group, 1 baby had a similar oil-related diarrhea, while the other was infective–(stool culture grew *E. coli*). The coconut oil from this baby's drop bottle also grew the same organism. In the control group, 1 had loose stools associated with documented septicemia, while the cause in the other could not be identified. All these babies survived and went on to

TABLE II– *Clinical Profile of Newborns on Hypercaloric (Fat-Fortified)*

Parameters	Units	*Control group	Hypercaloric diet group milks fortified with: Safflower oil	Coconut oil
Number of babies enrolled	n	24	22	24
Mean birthweight	9 x ± SD	1437 ± 63.8 (1300-1500)	1387 ± 56 (1285-1480)	1399 ± 46.7 (1340-1485)
Mean gestational age	weeks x ± SD	32.6 ± 2.1 (29-34)	32 ± 1.8 (30-35)	31.8 ± 2.2 (28-34)
SGA	%	57	60	55.8
Age of enrolment	days x ± SD	6.6 ± 1.8 (4-9)	5.7 ± 1.6 (4-7)	6.1 ± 2.1 (3-7)
Period of study	days x ± SD	28.5 ± 7.4 (15-38)	26.4 ± 8.6 (17-42)	29.1 ± 5.4 (17-41)
Associated problems	n			
Sepsis		12	11	10
Hyperbilirubinemia		4	1	2
Hyaline membrane disease		3	0	2
Hypoxic ischemic encephalopathy		1	2	0
Apnea		0	3	2

complete the study after temporary discontinuation of oil.

All except the above 5 babies from the oil group tolerated oil well and none developed vomiting, gastric residuals or obvious steatorrhea.

Stool Fat *(Fig. 1)*

Although individual variability within the groups was striking, the trend was related to absent to 1+ stools fat in the control group (73.3%), 2+ to 3+ in the coconut oil group (54.5%) and 4+ in safflower oil group (50%) (Semi quantitative method, Davidson and Henry). Only 9% of safflower oil group and 20% of coconut oil group had no fat in the stool samples tested.

Serum Triglycerides *(Table III)*

As with stools fat, serum triglyceride levels showed marked individual variability within the groups. An increase in the values was seen in all the 3 study groups, after establishment of feeds, but the increase in the coconut oil group was significantly greater than the increase in the controls ($p<0.05$). No such difference was seen in the safflower oil group.

Growth *(Table III, Fig. 2)*

The mean weight gain per day, weight gain per kg per day and mean weekly increment in skinfold thickness were significantly greater in the coconut oil group as compared to controls ($p<0.05$). Although

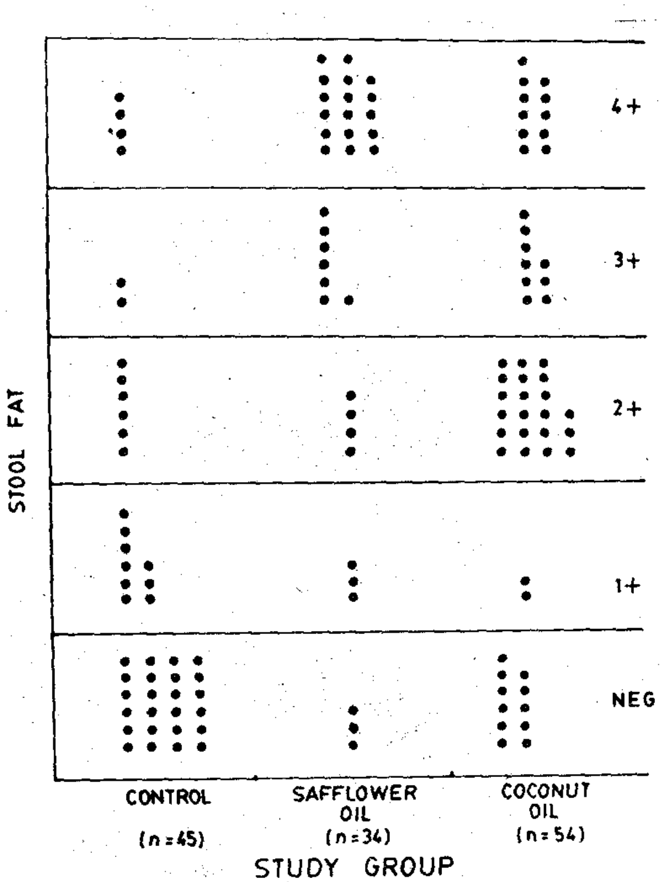

Fig. 1. Stool fat studies (semiquantitative method of Davidson and Henry) in babies on hypercaloric (fat-fortified) and control diet schedules.

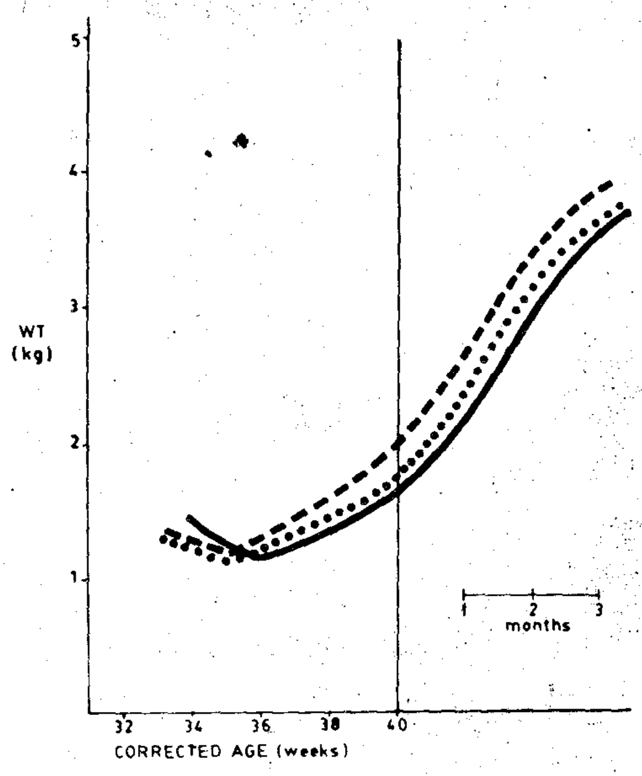

Fig. 2. Growth curves of babies on hypercaloric (fat-fortified) and control diet schedules (birth to corrected age 3 months).
———Control oil group
.... Safflower oil group
- - - - -Coconut oil group

TABLE III–*Growth and Serum Triglyceride Levels in Babies Receiving Hypercaloric (Fat-Fortified) and Control Diet Schedules*

Parameters	Units	Control group	Hypercaloric diet group milks fortified with	
			Safflower oil	Coconut oil
Nursery Stay				
Mean weight gain	g/day x ± SD (range)	11.59 ± 5.33 (1.3-20)	13.26 ± 6.58 (4.2-32.9)	19.47 ± 8.61 (8.75-36.9)
Mean weight gain	g/kg/day	8.06	9.56	13.91*
Mean weekly increase in triceps skinfold thickness	mm/week x ± Sd (range)	0.135 ± 0.16 (0-0.45)	0.183 ± 0.11 (0-0.4)	0.342 ± 0.17* (0.15-0.6)
Mean Serum Triglyceride Levels	mg/dl x ± SD (range)			
Before initiation of feeds		66.4 ± 13.7 (36-147)	66.2 ± 16.76 (41.5-182)	57.4 ± 12.14 (14.2-257)
7 days after establishment of feeds		85.8 ± 35.3 (44-159)	79.2 ± 13.9 (39.5-116)	118.47 ± 68.83 (38-220)
Increase in mean levels of triglycerides		19.4	13	61.07*
Follow Up				
Mean weight gain per day (discharge till corrected age of 3 months)	g/day x ± SD	22.8 ± 6.87 (14.1-31.57)	24.8 ± 5.86 (15.4-37.5)	29.85 ± 7.49 (17.5-40.4)

* Significant with respect to control group ($p<0.05$, Student 't' test)

these values were also greater in the safflower oil group as compared to controls, the differences did not reach statistically significant proportions.

Follow Up

The mean weight gain per day continued to be higher after discharge from the nursery in the oil group, as compared to the controls (although no oil fortification was made at home). However, these differences were not of statistically significant proportions. Growth curves of the babies in the 3 groups showed a distinct advantage in the oil groups (*Fig. 2*) till a corrected age of 3 months.

Discussion

A high energy formula will be of value only if it promotes increased energy retention and growth. Although sophisticated energy balance studies were not carried out, our study demonstrates increased growth velocities in the VLBW babies fed on oil fortified milks (*Table II*). It has been estimated that preterm babies absorb up to 65-75% of their dietary fat(16). As such, increase in dietary fat may lead to increased steatorrhea, but will also cause greater net fat absorption(17). Amongst the two oils used for fortification in our study, the weight gain was definitely superior in the coconut oil group as compared to the safflower oil group. In fact, only the coconut oil group achieved intrauterine growth rates of comparable fetuses.

Safflower oil contains a much higher content of essential fatty acids and the nutritionally superior PUFA(13), but these advantages are obviously negated because of poor absorption (as judged by the abundant stool fat). Coconut oil, on the other hand, proved superior presumably on account of its high content (up to 80%) of MCTs. MCTs have the advantage of direct absorption into the portal venous system, bypassing the inefficient digestive mechanisms of the preterm, *viz.*, low lipase levels and poor solubilisation by bile acids(19,20). Further, MCTs are rapidly oxidized and serve as a ready source of abundant energy(21).

It is for these reasons that MCT oil has long been popular in Western nurseries as a nutritional supplement(23,24). As commercially prepared MCT oil is expensive and generally not available in our country, the use of coconut oil, the rich source of MCTs *per se* seems a good inexpensive alternative. Incidentally preterm breast milk has a high content of MCT(25) perhaps signifying nature's recognition of the preterm's needs.

In spite of the strong theoretical advantages of MCTs, some carefully done energy balance studies(24,26) have failed to demonstrate any benefit of MCTs. Others have cautioned against the use of excessive amounts of MCTs as high concentrations may cause flatulence, vomiting and diarrhea(27), ketoacidosis(28) and serious lung complications(22). Bacterial contamination of oil as occurred in one of our babies is added risk in our situation.

It is difficult to understand the exact reasons for the apparent controversy regarding the value of MCT oil for fortification(1,9,10,24-26), but the varying reports probably relate to small numbers in the studies, short periods of study and wide individual variation within the subjects studies, short periods of study and wide individual variation within the subjects studied. In our study too, some babies from the control group showed higher growth velocities than the fortified groups. Therefore, fortification should be individualized, rather than become a routine nursery policy. Growth velocity is often quite satisfactory in the preterm on breast or proprietary milk alone; but in case of insufficient weight gain inspite of adequate volumes or where volumes have to be restricted, fortification with oils can be tried and expected to give a nutritional advantage.

The technique of addition of oil to feeds needs special attention. Premixing of oil to the feed and mechanical shaking can lead to a loss of up to 30% of fat as it tends to adhere to plastic containers and feeding tubes(29). Mechanical blenders can further activate lipases in milk and lead to lipolysis. Hence, the calculated amount of oil should be first gavaged into the tube and then flushed down with the milk. Such a technique is, of course, dangerous in the home situation. In view of the risk of contamination and aspiration of oil, we did not continue the study at home after discharge.

Finally, however, a fundamental question remains unanswered–Is the accelerated weight gain resulting from fat accretion really desirable? Using energy balance studies Reichmann *et al.*(30) demonstrated that weight gain induced by fat fortified milk modified infant's body composition with increased fat accretion, as compared to fetuses of similar postconceptional age. The consequences of these changes in body composition and its impact on lipid metabolism, obesity and vascular disease in later life deserve serious consideration. Effects of this accelerated weight gain subsequent catch up growth are now under investigation, in our study.

In conclusion, fat fortification of milk especially with MCT rich coconut is capable of enhancing growth velocities in VLBW babies. The technique of oil fortification needs special attention as this is fraught with dangers of aspiration and contamination. Further long term effects of such supplementation on growth and metabolism are under study; and hence, it is recommended at this juncture, that fortification be employed in certain selected situations only, rather than as a routine nursery policy.

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