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U.S.-ISRAEL COOPERATIVE DEVELOPMENT
RESEARCH PROGRAM.

Final Progress Report

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December 1990.

Title of Research Project:

Evaluation of Triglycerides as a rapidly assimilable Energy Source for
malnourished lactating Women and Children.

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OVERALL OBJECTIVES.

To investigate, in-vivo, the rate and extent of metabolism of medium chain triglycerides (MCT), relative to that of long chain triglycerides (LCT) in properly nourished and in malnourished humans.

To evaluate the efficacy of coconut oil as a locally available source of MCT for treatment of malnutrition in the tropics.

OBJECTIVES OF FINAL STAGE

The methodology employed is based on the differences in the ratio of the stable isotope ^{13}C to carbon ^{12}C in various foodstuffs. This ratio is referred to as delta C (δC). From the point of view of their delta C, the plant kingdom is divided into two groups: corn and pineapple, also referred to as C4 foods, having a comparatively high content of ^{13}C and all other plants having a relatively lower ^{13}C content. These latter plants are also referred to as the C3 plants, a term referring to the synthesis of their basic carbohydrate unit. Our theory, based on these facts was that if the body was stabilized on C4 foods, that is corn and pineapple, one could then add the C3 food to be tested and measure the effect of this food on the δC of the exhaled air and on breast milk. In our instance the food to be tested was MCT.

Previous experiments have shown that the C4 foods enter the metabolic pool within 60 minutes of ingestion and if their administration is continued during the whole day their metabolism continues to occupy an increasing share of the metabolic pool. Even after a night's fast the participation of C4 foods in the body's metabolism was still noticeable in the breath samples.

The present report deals with the definitive experiment under field conditions in the Philippines. It was undertaken in a sample of children suffering from malnutrition as well as from lactating mothers who were also underweight.

INDIVIDUALS AND METHODS.

As will be seen from Table 1. five children participated in the trial. Their ages ranged from 5-8 years and there was mild to moderate malnutrition as judged by the patient's weight and mild malnutrition as judged by height (Table 2). In most children, the weight was proportional to the height (Table 3).

The clinical data of the six lactating mothers are given in table 4. Most suffered from mild malnutrition. In addition there was one 18 year old male of normal weight and height (Randy)

The following diet was administered:-

Breakfast (all days).	Ingredients.	Adults	Children
	corn starch	1 cup	3/4 cup
	cream corn style	1/2 can	4 tbsp.
	eggwhite	2 pcs.	1 pc.
	sugar	2 tbsp.	1 tbsp.
Day 1.	corn oil	50 ml.	50 ml.
2.	no oil		
3.	coconut oil	100 ml.	75 ml.
4.	soybean oil	50 ml.	50 ml.
5.	cocnut oil	75 ml.	50 ml.
Lunch/Supper (all days)	corn starch		1/2 cup
	cream corn style		1 can
			75 ml. water.
	chicken cooked (lean meat)	25 gm	20 gm.

Breath collections were made at 0, 15, 30, 45 and 60 minutes and at 2,3,4,5,6 and 14 hours. A few also had a collection after 22-24 hours. The four dietary experiments were not performed on successive days.

Collections of breast milk depended on times of breast feeding. All milk fractions were separated into protein, lactose and fat fractions and SC was estimated in each fraction individually. Altogether some 675 samples of breath and breast milk components were analyzed in this group of experiments.

The daily caloric intake of the adults and children is given in tables 5 and 6 respectively.

RESULTS

Changes in Breath δC (Tables 7,8,9).

The introduction of a C4 containing diet, including the C4 oil, corn oil, caused a change in the δC of the breath samples in 7 out of 8 individuals within 15 minutes. In almost all individuals the peak was reached after 6 hours, although in one instance this occurred already after 2 hours. At 14 hours, which was several hours after supper, a slight drop was already apparent. A further drop was noticed in the two individuals that were tested after 23-24 hours.

Surprisingly, the diet of the second day, where no oil was added at all, did not differ significantly from that of the first day. The first changes were noticed at 15 minutes. Subsequently there was a biphasic curve with peaks at 3 and at 6 hours. The absolute rise from the baseline was no different from that of the first day.

The introduction of the MCT containing oil, coconut oil, resulted in slightly lower δC values than were found on the previous two days, but not significantly so.

The long chain triglyceride oil, soy oil, also showed a change of δC at 15 minutes already and subsequently a biphasic curve with peaks at 3 and 6 hours. Once again the a slight effect was still noticeable after a night fast.

The depression of the δC oil, coconut oil, was again noticeable in the 3 individuals given 75 ml of this oil.

Changes in breast milk δC . (Tables 10,11,12).

The C4 diet was incorporated into the breast milk fat within 2 hours and reached a peak at 10 hours. This phenomenon was present even when no oil was added to the diet, suggesting that the C4 milk fats were not derived entirely from dietary fat, but rather from carbohydrates. The C3 oils, coconut oil and soy oil did not prevent a rise of δC providing further support for the possibility that some of the milk fat was derived from carbohydrate and not from fat only.

The rise of δC in lactose was more rapid and more substantial than that after fat. Again a peak was reached after 10 hours.

The rise after protein was more modest than that after lactose but more marked than that after fat. This indicates that in the two hours which have elapsed since the meal, the protein has been digested,

resynthesized into milk protein and secreted into breast milk.

CONCLUSIONS.

1. The use of naturally occurring stable isotopes is a useful tool for studying the synthesis of carbohydrate, fat and protein in breast milk.
2. Carbohydrate appears to be incorporated into breast milk rapidly and to a greater extent than fat and protein, although all three constituents can be detected within 2 hours and reach a peak ten hours after ingestion.
3. The ingestion of C4 containing foods can be detected in the breath within 15 minutes. It did not prove possible to distinguish between the effects of medium and long chain fatty acids, nor between fats as a whole and proteins and carbohydrates.

Table 1. Weight for Age Classification

N A M E	AGE (year)	WEIGHT (kg)	Standard Weight for Age	% Standard	Classification (Gomez)
1. Katherine Delmo	5	13.5	16.9	79.9	First degree/mild
2. Ma. Cecilia Villanueva	5	13.8	16.9	81.7	First degree/mild
3. Rogelio Lagarto	6	13.7	18.3	72.9	Second degree/moderate
4. Hedeliza Biojon (HEDI)	6	16.8	20.0	84.0	First degree/mild
5. Lilibeth Delmo	7	15.5	20.5	75.6	First degree/mild
6. Rommel Lagarto	8	19.7	22.8	86.4	First degree/mild

Table 2. Height for Age Classification.

N A M E	AGE (year)	HEIGHT (cm)	Standard Height for Age	Z Standard	Classification (McClaren)
1. Katherine Delmo	5	97.8	105.8	92.4	Mild
2. Ma. Cecilia Villanueva	5	97.0	105.8	91.7	Mild
3. Rogelio Lagarto	6	104.1	112.0	92.9	Mild
4. Hedeliza Biojon (HEID)	6	110.5	116.0	95.3	Normal
5. Lilibeth Delmo	7	106.7	117.8	90.6	Mild
6. Rommel Lagarto	8	117.1	123.5	94.8	Mild

Table 3. Weight for Height Classification.

N A M E	WEIGHT (kg)	HEIGHT (cm)	Standard Weight for Height	Z Standard	Classification (Waterlow)
1. Katherine Delmo	13.5	97.8	14.6	92.5	Normal
2. Ma. Cecilia Villanueva	13.8	97.0	14.6	94.5	Normal
3. Rogelio Lagarto	13.7	104.1	16.8	81.5	Mild
4. Hedeliza Biojon (HEIDI)	16.8	110.5	18.6	90.3	Normal
5. Lilibeth Delmo	15.5	106.7	17.4	89.1	Mild
6. Rommel Lagarto	19.7	117.1	20.7	95.0	Normal

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TABLE 4

N A M E	HEIGHT (cm)	DESIRABLE BODY WT. *	ACTUAL WEIGHT	% STANDARD	CLASSIFICATION
1. Leyda Cervantes	152.6	kg. 47.34	kg. 41.0	87.3	Mild
2. Matilde Lagarto	153.7	48.33	41.5	85.6	Mild
3. Rosario Mabesa	149.2	44.28	36.5	82.4	Mild
4. Sheila Lapidario	152.4	47.16	42.0	89.2	Mild
5. Virginia Alinas (INIANG)	152.4	47.16	41.5	87.9	Mild
6. Adelia Villanueva	152.4	47.16	46.5	98.6	Normal
7. RANDY ARAMBILD **					

* by Lannhauser's

AN 18-YR. OLD MALE WHO IS 5 FEET 4 INCHES IN HEIGHT AND IS 100% NORMAL AS COMPARED TO STANDARD. I WAS NOT ABLE TO BRING HIS EXACT WEIGHT BECAUSE I LEFT IT IN CABUYAO.

Table 5.
CALORIC INTAKE OF ADULTS (In kCal).

Name	Day 1	Day 2	Day 3	Day 4	Day 5.
	Corn oil	No oil	Coconut	Soy oil	Coconut oil.
			oil		
Mathilde	1800	1050	2100	1500	1600
Rosario	1800	1250	2100	1500	
Adelia	1800	1300	2100	1500	
Inyang	1800	1300	2100	1500	
Randy	1800	1300	2100	1500	2100

Caloric distribution (per cent of total calories)

				Randy	Mathilde
Carbohydrate	60%	80%	50%	60%	50%
Protein	10%	15%	10%	10%	10%
Fat	30%	5%	40%	30%	40%

Table 6.
CALORIC INTAKE OF CHILDREN (In kCal)

Name	Day 1	Day 2	Day 3	Day 4	Day 5
	Corn oil	No oil	Coconut	Soy oil	Coconut oil
			oil		
Cecilia	1250	900	1050	900	
Rogelio	900	900	950	650	
Heldi	900	850	1050	850	800
Lilibeth	900	900	900	1000	

Caloric distribution (percent of total calories).

Carbohydrate	60%	85%	50%	60%	50%
Protein	10%	10%	5%	10%	5%
Fat	30%	5%	45%	30%	45%

TABLE 8

INCREMENTS OF DELTA C IN BREATH ON VARIOUS DIETSCOCONUT OIL(MCT) 12.4.89

	<u>Cecilia</u>	<u>Heidi</u>	<u>Lilibeth</u>	<u>Adelia</u>	<u>Iniang</u>	<u>Rogelio</u>	<u>Rosario</u>	<u>Randy</u>	<u>Mathilda</u>	<u>Mean</u>	<u>S.D.</u>
0											
15'	0.4	2.9	1.7	3.4	3.6	2.7	3.7	2.8	2.3	2.6	± 1
30'	0.5	4.4	3.9	4	4.1	3.4	4.8	2.5	2.8	3.4	± 1.3
45'	1	5	4.6	4.4	5.1	4.4	4.8	3.1	3.3	3.9	± 1.3
1 Hr.	2.8	5.3	5.1	5.3	4.6	4.2	5	3.7	3.7	4.4	± 8
2	3.8	6.1	7.9	5.5	6.3	5.1	5.6	4.7	4.8	5.5	± 1.2
3	3.2	7.9	8.7	7.1	6	5.2	6.2	6.5	6.3	6.3	± 1.6
4	3.5	7.4	6.4	6.6	5.1	4.9	7.2	5.8	5.2	5.8	± 1.2
5	4	7.4	5	5.1	5.4	5.3	7.7	4.2	4.8	5.4	± 1.3
6	4.4	6.1	4.2	6.2	6.2	4.3	8.5	4.7	6.1	5.6	± 1.4
14	0.4	3.2	8.1	5.6	7.9	5.5	6.8	4.3	2.6	4.9	± 2.6
23			2.9			2.3					

SOY OIL 12.9.89

										<u>Mean</u>	<u>S.D.</u>
0											
15'	3.2	2.2	3.1	2.9	1	3.5	2.6	1.2	2	2.4	±
30'	4.8	4.4	4.3	4	2.2	3.5	3.9	1.6	3	3.5	± 1.1
45'	5	5.2	4.6	3.8	3.3	5.1	4.5	2.4	4.3	4.2	
1 Hr.	6	5.7	5.4	4.8	3.5	3.3	5.5	3	5.4	4.7	± 1.1
2	7.3	6.3	6.8	7.7	6.5	3.9	7.2	5.1	7.4	6.5	± 1.2
3	8.9	5.3	7.2	8.7	8.1	3.3	8.9	5.9	8.4	7.2	± 1.9
4	9.4	4.7	7.5	7.8	8.4	2.7	8.4	5.2	6.5	6.7	± 2.2
5	8.6	2.3	5.7	7	7.9	2.5	9.2	4.2	6.1	5.9	+ 2.5
6	8.8	3.9	7.3	8.3	8.8	3.6	9.3	5.7	6.9	6.9	± 2.1
14	7.7	2.2	6.4	4.8	7	3.7	6.9	4.5	4	5.2	± 1.8
22		0.6	0.7		2.4	0.1					

12'

TABLE 9

INCREMENTS OF DELTA C IN BREATH ON VARIOUS DIETS

COCONUT OIL 75 ml. 12.14.89

	<u>Heidi</u>	<u>Randy</u>	<u>Mathilda</u>	<u>Mean</u> ⁺ <u>S.D.</u>
0				
15'	1.9	1.2	1.6	1.6 ₋ ⁺
30'	2.8	1.6	2.1	2.2 ₋ ⁺
45'	3.8	3	2.8	3.2 ₋ ⁺
1 Hr.	3.6	3.6	3.9	3.7
2	4.9	6.4	5.9	5.7
3	4.6	6.6	6.4	5.9
4	3.9	6.4	7.2	5.8 ₋ ⁺ 1.7
5	3.1	4.5	5.7	4.4 ₋ ⁺ 1.3
6	4.9	5.8	6.2	5.6 ₋ ⁺
14	4.6	8.1	4.5	5.7 ₋ ⁺ 2

TABLE 10

INCREMENTS OF DELTA C IN BREAST MILK COMPOSITION

<u>FAT 11.24.89 (Corn Oil)</u>					
<u>Hrs.</u>	<u>Adelia</u>	<u>Iniang</u>	<u>Rosario</u>	<u>Mathilda</u>	<u>Mean</u>
0-2	0			0.7	0.7
2-5.5		0.3	1.2		0.75
5.5-10	3.2	3.3		4	3.5
10-14	5		4	4.2	3.8
20-24	5				5
11.29.89 (No Oil)					
0-2	0.4	0.1	0.2	1.1	0.45
2-5.5	1.2	0.6			0.9
5.5-10	2.4	1	3.3	2.4	2.2
10-14	2.7	1.7	5.2	2.3	2.9
20-24			2.7	0.3	1.5
12.4.89 (Coconut Oil (MCT))					
0-2	0.1	0.1	1.4	0.7	0.5
2.1-5.5	0.5	0.1	2.9	1.4	1.2
5.5-10	1.3	0.5	3.3	1.2	1.6
10.1-14					
20-24					
12.9.89 (Soy Oil)					
0-2	0.6	0.2	1	1.1	0.72
2.1-5	1.5				1.25
5.1-10	1.3	0.5/1.5	1.3/1.4	1.5	1.1
10.1-14	1/5			1.5	1.5
20-24			2.7	1.3	2
12.14.89 (Coconut Oil 75 ml.)					
0-2				0.5	0.5
2.1-5					
5.1-10				1.7	1.7

TABLE 11

INCREMENTS OF DELTA C IN BREAST MILK COMPOSITION

PROTEIN11.24.89 (Corn Oil)

Hrs.	Adelia	Iniang	Rosario	Mathilda	Mean
0-2	0.1				0.1
2-5.5		5.5	2	0.6	2.7
5.5-10.1	5.7	7.4	1.7	2.3	5.7
10.1-14	3.2		5.3	4.1	4.2
20-24	2.9				
11.29.89 (No Oil)					
0-2	0.7	0.1	2	3.8	1.9
2.1-5.5	3.8	5.8	3.4	2.1	3.8
5.5-10	6.1	3.8		5	4.9
10.4-14	2.6	3.8	4.8		3.7
20-24			3.1	1.8	2.5
12.4.89 (Coconut Oil)					
0-2	3.5	-1	1.6	3.2	2.8
2.1-5.5	3.8	-2.4	3.7	2.7	3.4
5.6-10	2.9	-2	4.1	1.9	3
10.1-14					
12.9.89 (Soy Oil)					
0-2	1.8	3.1	0.9	5.5	2.7
2.1-5.5	5.2	0.5	6.2	1.5	3.4
5.6-10	3.3	0.6	1.8	3.7	2.4
10.1-14	1.8			2.9	2.4
14-20			2.5	2.1	2.5
12.14.89 (Coconut Oil 75 ml.)					
0-2				1.3	
2.1-5.5				2.6	
5.6-10				4.9	

TABLE 12

INCREMENTS OF DELTA C IN BREAST MILK COMPOSITION

LACTOSE11.24.89 (Corn Oil)

Hrs.	Adelia	Iniang	Rosario	Mathilda	Mean
0-2	4.7		5.8	4.8	5.1
2.1-5.5		5.7			5.7
5.5-10	10	6.5	11.5	9.7	9.5
10.1-14	12.4		10.7	7.9	10.3
20-24	2				2
11.29.89 (NO Oil)					
0-2	3	2	3.2	6.9	3.7
2.1-5.5	8.4	8.1	11	8.6	9
5.5-10	9.9	9.6		7.6	9
10.1-14	6	9.4	8.7		8
20-22			10.9	1.3	6.1
12.4.89 (Coconut Oil)					
0-2	5.2	-5	5.4	4.8	5.1
2.1-5.5	9.4	(1.3)	9.7	8.4	9.4
5.5-10	11.1	4.1	11.4	4.3	7.7
12.9.89 (Soy Oil)					
0-2	4	1.4	6.5	5.9	4.45
2.1-5.5	10	6.5	10.4	9.1	9
5.5-10	10.5	6	11.4	9	9.2
10.1-14	9.9			6.3	8
20-24			4.5	3.2	3.9
12.14.89 (Coconut Oil 75 ml.)					
0-2				6.6	
2.1-5.5				2	
5.5-10				2.2	