Bull Philipp Biochem Soc 9:17-19 (1990)

Assimilation of Nutrients by the Mammary Gland as Indicated by Delta C Analyses of Dietary and Breast Milk Components

Nieva T. Librojo[1]* and Gerald L. Schroeder[2]

[1]Institute of Chemistry, CAS, University of the Philippines Los Baños, College, Laguna

[2]Department of Animal Sciences,
ARD Volcani Center, Bet Dagan, 50250 Israel

The almost immediate assimilation of ingested foods into breast milk was demonstrated by measuring changes in the breast milk's delta C values relative to changes in diet delta C. The carbon of dietary carbonates accounted for over half the lactose and protein fractions of the milk within 4 and 8 h, respectively, of the consumption of the carbohydrate. The results support an understanding that the current diet of a nursing mother intimately and rapidly effects the composition of her secreted milk.

Keywords: Delta C analyses, breast milk, nutrient assimilation.

The delta C (a measure of the ratio of the 2 stable isotopes of carbon, 13 C: 12 C) of an animal's muscle (or other proteinaceous tissue) has been shown to be a valid indicator of that animal's dietary delta C during the period in which the muscle grew. This has allowed delta C to be used as a quantitative indicator of dietary assimilation for situations in which the diet has remained constant over long periods of time [3,4]. For land and aquatic animals and fowl, the delta C of the muscle tissue was demonstrated to average 0.8 o/oo (S.D. 0.8 o/oo) less negative than the diet delta C, provided that the diet had been constant during a >5-fold weight gain [4]. When diets were held constant for short periods (3 weeks), specimens of muscle, blood serum, saliva and newly grown hair had delta C values intermediate to the current diet's delta C and the delta C of previously stored body tissues. In this report, we describe the rapid delta C response of breast milk fractions to changes in diet delta C.

MATERIALS AND METHODS

Four adult mothers who were nursing 3 times daily were provided with one of 4 nutritionally balanced diets having selected, pre-determined delta C values. All foods were of natural origin and typical of the conventional local diets. No enrichment of the 13-C isotope was used. Unlimited amounts of water were permitted. Subjects consumed each of their diets for several consecutive days and in a cross-over design, switched to alternate diets. Samples of breast milk, fractionated by centrifuge into lipid, lactose and protein prior to delta C analysis, were taken immediately following each nursing. Delta C analyses of replicate samples agreed to within 0.2 o/oo. The results of all tests were consistent. Two representative cases are presented in this paper.

Informed consent was obtained from all volunteers after the nature and possible consequences of the studies had been fully explained to them.

RESULTS AND DISCUSSION

In a study in Israel, protein sources (ocean fish delta C-19 and milk delta C-21) and vegetables and fruits (all C-3 type plants, delta C-25 to -27) were kept constant while the main carbohydrate was changed from wheat (a C-3 grain, delta C-25) to corn (a C-4 grain, delta C-11) and then returning after 3 days to wheat. The delta C of the whole breast milk, its lactose, lipid and protein during this dietary regime are shown in Figure 1. The changes in the diet, as indicated in the figure, took place after breakfast. By the time of the first sampling following the diet's change (i.e., the next nursing some 3 to 4 hours later), the lactose delta C had changed by 6 o/oo (from the pre-corn value of -22 toward the corn delta c value of -11) and reached a new equilibrium value of -16. Protein delta C changed more slowly, taking 24 h to reach the new equilibrium delta C value. For both the lactose and the protein, the 6 o/oo change represented over 55% of the difference between the pre-corn delta C value and the delta C of the corn. This indicated a > 55% contribution of the corn to these 2 milk fractions. In contrast to the lactose and protein, the milk lipid showed only slight variations during the course of this diet.

In a study in the Philippines, the entire diet was changed from C-3 foods (delta C-25 to -27) to C-4 foods (delta C-11 to -13) and then returning to C-3. The results

* To whom correspondence should be addressed.

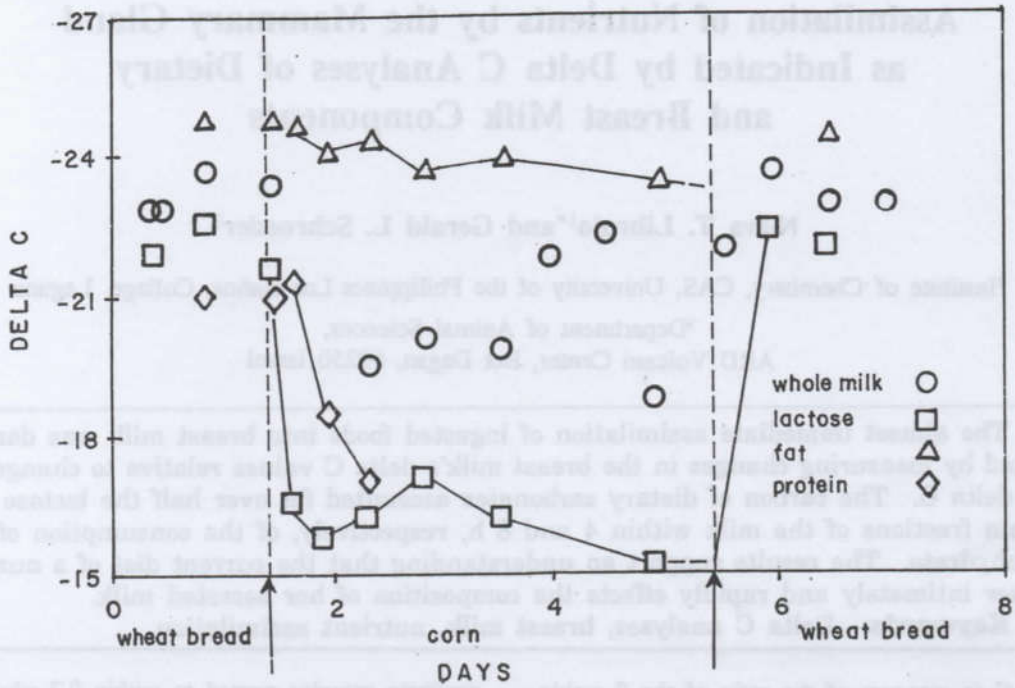

Fig. 1. Delta C values of breast milk fractions sampled from a mother nursing 3 times daily during a diet change in which wheat products (Delta C-25) were replaced with corn (Delta C-11) and then returned to wheat. All other parts of the diet remained constant during the test period.

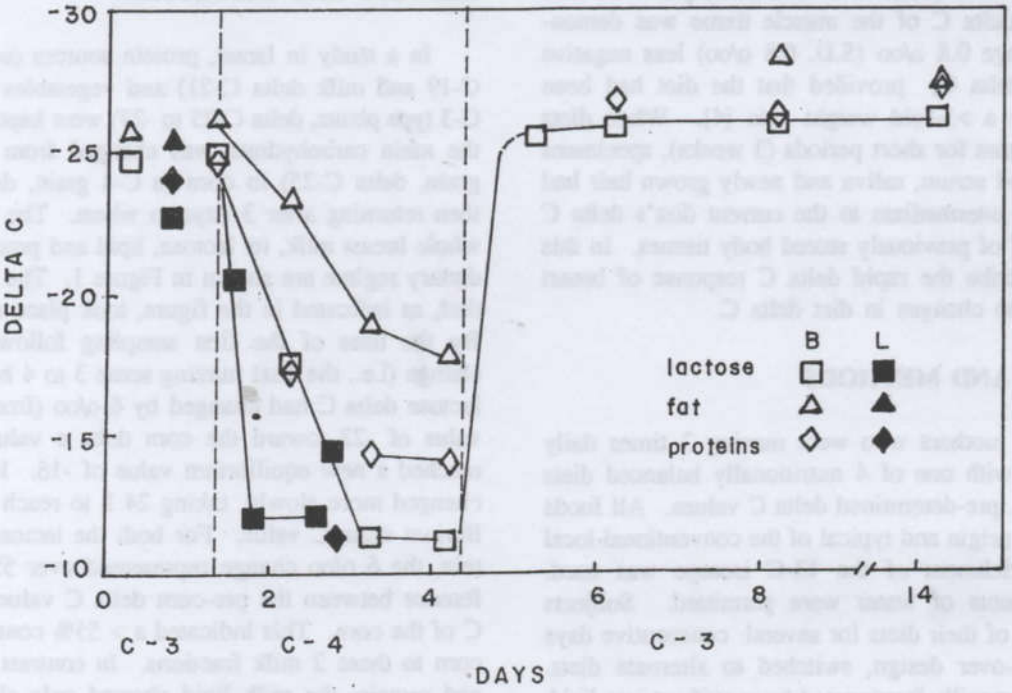

Fig. 2. Delta C values of breast milk fractions sampled from a mother nursing 3 times daily during a diet change in which an all C-3 type diet (delta C-25 to -27) was changed to all C-4 type diet (delta C-11 to -13) and then returned to C-3 type foods. B represents breast milk samples taken prior to breakfast. L represents samples taken during the afternoon or evening.

are shown in Figure 2. Again, the changes in diet delta C rapidly appeared in the lactose and protein of the breast milk. Note that in the first 24 h, the pre-breakfast samples, coming after the all-night fast, had delta C values which reflected a mixture of the previous and current diet delta C's. By evening of the first day (8 h after the diet change), the lactose delta C matched exactly the delta C of the new diet. The lactose carbon was already being composed totally of recently ingested food. By the following evening, the carbon of both the lactose and the protein were being formed completely from the current diet.

The fact that the delta C of the milk lipid was 2 o/oo to 6 o/oo more negative than the milk carbohydrate (lactose) or protein delta C is typical of all plant and animal tissues and is related to isotopic fractionation in the biochemical path by which the lipid is formed [2].

None of the other body specimens we tested (blood serum, saliva, new hair, facial shavings, urine) responded as rapidly or completely to dietary changes as did the lactose and protein of breast milk. The delta C of breath carbon dioxide responded to diet changes within an hour. But, even after 3 weeks of a constant diet, the breath delta C indicated that metabolic energy was originating from a mix of body tissue and current diet, rather than solely the current diet.

The rapid response of breast milk delta C to diet delta C emphasizes the aggressive manner in which the body allocates incoming nutrients in order to provide an adequate diet to its offspring. It also shows the major contribution which the carbohydrate of a diet makes to both the carbohydrate and protein of the milk. It implies a need for regular consumption of carbohydrate-rich foods by a nursing women. A similar quantitative response to diet delta C was reported for lactose and protein in bovine milk [1]. In that study, the equilibrium between diet delta C and the delta C of the lipid and protein was reached after 4 days, a reflection of the mixing and longer retention time of foods in the bovine rumen as compared with the monogastric human stomach.

ACKNOWLEDGEMENTS

The authors thank the United States Agency for International Development - Cooperative Development Research Program for the financial support granted, and Mrs. Teresita O. Magpantay for the fractionation of the milk samples obtained in the Philippines.

LITERATURE CITED

1. Bruckental, I. and G. Schroeder. 1986. Proc. Conf. on Comparative Aspects of Physiology of Digestion in Ruminants. Cornell U.
2. DeNiro, M. and S. Epstein. 1977. Mechanism of carbon isotope fractionation associated with lipid synthesis. Science 197:261-263.
3. DeNiro, M. and S. Epstein. 1978. Influence of diet on the distribution of carbon isotopes in animals. Geochim. Cosmochim. Acta 42:495-506.
4. Schroeder, G. and D. Ben-Ghedalia. 1986. The fate of dietary components in sheep digesta as indicated by stable carbon isotopes. Nutr. Rpts. International 34:691-699.