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# Infant Nutrition: Correcting Our Mistakes

by Buck Levin, Ph.D., M.A., R.D.

## Introduction

As a registered dietitian, there is no perspective which upsets me as much as the perspective which is taken by my professional organization (The American Dietetic Association, or ADA) toward infant nutrition. Yes, I know about Mead Johnson and Ross Laboratories. These are the two largest manufacturers of infant formula worldwide. Together they gave almost half a million dollars last year to the ADA's National Center for Nutrition and Dietetics, and provided more scholarships in dietetic education than any other U.S. organizations. Yes, I know about the National Dairy Council and National Dairy Board. These organizations teamed up with the ADA in 1994 to conduct the Nutrition and Health Campaign for Women. The Dairy Council also provided funding for development of fact sheets on bone health, which were produced through the ADA's National Center for Nutrition and Dietetics and mailed out to all 60,000 registered dietitians in the U.S.

I know about these organizations, and the political relationship they have with the ADA. But it's still hard for me to accept the amount of scientific research which is currently being ignored by the ADA in its production of healthcare professionals supposedly trained in the nourishment of infants.

We don't have to look far to find recent pioneering research in infant nutrition. Thanks to the work of Rolf Zetterstrom and colleagues at the Karolinska Institute in Stockholm, Sweden, we know about the affects of early infant feeding on the micro-ecology of the gut. From the work of Margaret Neville at the University of Colorado Health Sciences Center we know about the effects of xenobiotics (toxins) on milk secretion and composition. From Karajalainen's work in Canada and Finland, we know about the role of ABBOS - a 17 amino-acid polypeptide contained in bovine serum albumin. We know exactly how the body forms antibodies to this polypeptide when milk protein is consumed by infants, and how these antibodies can react with p69, a beta-cell surface protein on the infant's pancreatic cell membranes, thus initiating a series of events which can lead to the destruction of the cells and the onset of juvenile onset insulin-dependent diabetes.

What has been scientifically documented in the past ten years about infants and their nutrition is nothing short of astounding. What follows is a brief review of several key areas in infant nutrition and some suggestions for correcting our mistaken approach to infant nourishment.

**Preconceptual Nutrition**

The most visible call-to-action in infant nutrition has resulted from a growing number of studies on folic acid, neural tube defects (NTDs), and maternal folate status preconception. Primary prevention of NTDs through maternal folate supplementation pre-pregnancy was initially reported in the literature as early as the1980s, with articles appearing in the British Medical Journal (1) and Lancet (2). Since that time repeated studies have shown that mothers of NTD children have consistently higher levels of homocysteine in their blood, and that prophylactic use of folate can help reduce these levels by restoring function to the enzyme methionine synthase. This enzyme is responsible for converting homocysteine into methionine, a process which apparently gets compromised in mothers of NTD children through lack of available folate in the form of 5-methyl-tetrahydrofolate which is needed as a cofactor by this methionine synthase enzyme.

Despite the critical importance of folate sufficiency pre-pregnancy, it remains only one of many important nutritional issues involving the period of preconception which has been explored in the past ten years. In 1991, for example, Feichtinger and colleagues, writing from the University of Vienna Medical School in Vienna, Austria, published a review of environmental factors and fertility which examined the relationship between conception and toxic residues like PCBs - polychlorinated biphenyls, the commonly-appearing water and soil contaminants which originate in plasticizers, waxes, and electrical products; insecticides like gamma hexachlorocyclo-hexane (HCH), dichlorodiphenyltrichloroethane (DDT), and dieldrin; fungicides like hexachlorobenzene (HCB); and cigarette smoke. What Feichtinger and others have found is a trend toward inability to conceive with increasing exposure to environmental pollutants; increased nutritional demands on the body in the face of toxic exposure; and increased incidence of birth defects in women who do conceive.

Even without the added risks to conception posed by environmental pollutants, women of child-bearing age in the U.S. are at risk from the standpoint of dietary intake itself. From data reported in the United States Department of Agriculture (USDA) Nationwide Food Consumption Surveys, and the Second National Health and Nutrition Examination Survey (NHANESII), we know that women between 15 and 44 years of age have sub-RDA (Recommended Dietary Allowance) intake of

vitamins B-1, B-3, B-6, C, and folate, as well as sub-RDA intake of the minerals calcium, magnesium, iron, copper, zinc, and manganese.

Coupled with this list of nutrition and nutrition-related factors which can compromise preconception is the increasing presence of unwanted pregnancies in the U.S. A 1987 report in the New England Journal of Medicine estimated that 72% of all U.S. women between 15-44 years of age experience an unwanted pregnancy, and that 92% of these women had used some method of contraception at the time of the unwanted pregnancy. Since development of many of the major fetal organs requiring these nutrients is known to occur before 12 weeks in utero - organs including the brain, lungs, liver, skeleton, and nervous system - this constellation of sub-RDA nutrition, unplanned pregnancy, and environmental toxic exposure should be high on the list of national nutritional priorities. It should also be enough to justify ADA endorsement of dietary intervention - including vitamin/mineral supplementation - for all women of child-bearing age, regardless of contraceptive practice or intent. Such an endorsement should replace the current and mistaken ADA position that supplementation of iron during the second and third trimester, together with supplementation of calcium, folate, and B-6 begining in the first trimester for "pregnant adolescents at risk for inadequate food consumption" are the only properly timed and justifiable interventions. (2B)

**Breastfeeding**

In 1930, some 12 years before the initial rise of Gerber's Baby Foods in the U.S.and prior to the widespread acceptance of infant formulas, 90% of all mothers breastfed their infants, and rarely introduced solid foods before one year of age. (3) By the early 1970's, the percentage of U.S. infants being breastfed after 6 months of age had dropped to nearly 5%. Today it is common to see infants formula fed from day one of life, and to see commercial baby foods fed to infants less than two months of age. The current ADA position paper on infant nourishment promotes 5-6 months of age as a target goal for maintenance of breastfeeding, and 4 months of age as a low risk and potentially necessary moment for introduction of food or drink to a breastfeeding infant. (4B)

Studies from Gambia, (5) Botswana, (6) West Africa, (7) Switzerland, (8) and China (9) on the effects of prolonged lactation help re-establish a worldwide perspective on breastfeeding in which duration is measured not in months but in years. For most infants worldwide, human milk is the major source of nutrients for the first two years of life, and it is not uncommon for infants to receive some nourishment from the mother's milk up until three or four years of age. Several researchers have noted protective effects of prolonged lactation on maternal

health, including decreased risk of endometrial (10) and breast (11) cancers. But the major benefits of breastfeeding belong to the infant.

## Macronutrients

The protein, carbohydrate, and fat components of human milk are significantly different in quality from commercial formula. In the case of protein, human milk is almost twice as high in the amino acid cysteine, and 25% lower in methionine, than cow's milk. It is also higher in the sulfur-containing amino acid taurine, as well as in nonprotein nitrogen. Human milk is also surprisingly low in the amino acids phenylalanine and tyrosine. The cysteine-methionine balance is important, since the fetal liver cells lack the enzymes for converting methionine into cysteine, and this capability develops at varying rates in young infants. The low levels of phenylalanine and tyrosine are also important, since the baby's liver can be slow to develop the enzymes for metabolizing these amino acids. The relatively high concentrations of taurine are also critical, since brain taurine concentrations have been shown to peak during neonatal life (12), and formula-fed pre-term and full-term infants have been shown unable to maintain plasma taurine levels comparable to breastfed infants (13), (14).

## Protein and Immunity

The question of protein in human milk also takes us into the realm of immunology, since human milk contains significant concentrations of the protein antibodies IgA, IgM, IgG, and secretory IgA (sIgA). These immune factors protect the infant from a variety of bacteria. Also included in human milk are small proteins which can block viruses from attaching to cells, protein enzymes which can disrupt the cell walls of bacteria, and binding proteins which can hook up with iron, remove it from disease-causing bacteria, and prevent those bacteria from reproducing. None of these factors, of course, are available in any commercial formula.

But perhaps most important issue with respect to infants and protein is the incompatability of non-human milks in terms of allergenicity. We know that within the curd protein of cow's milk are caseins and other proteins to which many infants are sensitive. In the most extreme instances, sensitivity to cow's milk has been linked with anaphylaxis and cot death/Sudden Infant Death (SIDS). (15) Increased levels of the IgG antibody in the lungs of SIDS infants accompanied by the presence of cow's milk antigens in a high percentage of these same infants has served as the basis for this linkage. Heyman and colleagues working out of the Hospital St. Lazare in Paris have determined that intestinal permeability is increased in infants allergic to cow's milk by virtue of increased secretion of tumor necrosis factor alpha from the mononuclear cells of

those infants. (16) This process renders the infant susceptible to a variety of gastrointestinal disorders.

In this same gastrointestinal context, we've learned that infants fed cow's milk formula develop a substantially different set of bacteria in their intestines, headed up by large populations of enterococci, coliforms, and Bacteriodes, but consistently low in bifidobacteria, lactobaccili, and staphylococci. (17) We also know that major ecological disturbances to the gut - like the use of antibiotics - can further upset the bacterial balance, and that human milk, unlike commercial formula, can help restore this balance. (18)

Finally, we have numerous reports of infants being treated for allergic rhinitis, bronchial asthma, atopic eczema, atopic dermatitis, colic and chronic constipation who have high levels of cow's milk antibody in their blood and who respond favorably to dietary treatment which eliminates dairy products. (19) (20) (21) (22) (23) Most dramatic in this area of immunological mis-match between cow's milk proteins and the infant's immune system has been the discovery that cow's milk protein is likely to trigger an autoimmune response in geneticaly susceptible infants which results in the destruction of the beta cells of the infant's pancreas and the onset of insulin-dependent diabetes mellitus. Publishing in the New England Journal of Medicine in November of 1992, Karjalainen and colleagues reported the presence of 650% higher levels of anti-BSA (bovine serum albumin) antibodies in the serum of 142 children with insulin-dependent diabetes versus 79 healthy children. In addition, whereas 100% of these insulin-dependent children had elevated levels of anti-BSA antibody, only 2.5% of the 79 healthy children had small amounts of antibody specific to bovine serum albumin. (24) Karjalainen and his colleagues have also shown that a 17-amino acid peptide group - found within the albumin protein contained in cow's milk but not found within the albumin protein contained in human milk - can migrate in the blood directly to a surface protein called p69 on the membranes of beta cells located in the infant's pancreas, bind with that surface protein, and initiate an immune response which results in the pancreatic cells being rendered dysfunctional and incapable of producing insulin. Thus, in genetically susceptible infants, intake of cow's milk has been linked to the risk of juvenile onset insulin-dependent diabetes.

Carbohydrate

Like protein, the carbohydrate content of human milk is unique, and an important part of this uniqueness lies in its high concentration of milk sugar, or lactose. This lactose can be broken down into the simple sugars glucose and galactose. On a per-calorie basis, more galactose is needed during infancy than during any other period of development, in order for the body to keep up with synthesis of the galactose-rich coating which is used to insulate the infant's

nervous system. Equally important is the rich supply of the protein enzyme lactase in human milk. Because many infants cannot make enough of this enzyme needed to break lactose into its simple sugar components, human milk supplies the infant with the tool (lactase) as well as the raw material (lactose). Cow's milk, by comparison, contains only two thirds the lactose of human milk (4.8% versus 7%), and virtually no lactase with which to digest it. (25)

Fat

Like protein, the fat content of human milk is important for what it does, and what it doesn't contain. We'll start with what is naturally absent - namely, trans fatty acids.

Almost 20 years ago, the journal Federation Proceedings reported that as much as 10% of total caloric intake in the U.S. might consist of trans fatty acids - a naturally but relatively rarely occurring form of fat which is produced in high concentrations when oils are hydrogenated in the food processing industry. What we've learned more recently is that human milk is virtually free of trans fatty acids, unless formula containing this type of fat is introduced to the infant, or unless the mother's diet contains significant amounts of it. Rate of maternal weight loss postpartum appears to be a key variable controlling the transfer of trans fatty acids to the nursing infant, with quick weight losses being associated with increased release of trans fatty acids into the milk. (26) Although the implications of this trans fat intake during infancy are not yet clear, adult intake of trans fat has been shown to adversely affect balance of fat in the blood and incrase the risk of heart attack. (27)

What's present in the fat content of human milk has also been the subject of extensive investigation in the past ten years. Here the most important findings involve the fatty acids DHA (docosahexaenoic acid) and GLA (gamma linolenic acid). DHA, the 22-carbon omega 3 fatty acid with 6 double bonds, has been shown to be critical in the brain and retinal development of the infant. (28) This fatty acid is also known to be plentiful in human milk, which contains approximately 300 milligrams of DHA per 100 grams of total fat. (29) As a comparision, the plant oils generally used in the manufacture of infant formula - corn and soy - contain no DHA. These differences are have been further reflected in studies showing that the red blood cells of breastfed versus formula fed infants contain 40% more DHA, and cells from the cerebral cortex - 13% more. (30) Researchers at the University of Texas Southwester Medical Center have recently shown that supplementation of DHA- and EPA-enriched formula to premature infants improves rod photoreceptor function, visual acuity, and cortical function in those infants. (31) Because fish oils contain high amounts of DHA, some researchers have suggested that infant formulas be supplemented with these oils. In addition to questions of palatibility and stability, however, fish oil

supplementation may also give rise to concern since fish oils are also high in eicosapentaenoic acid (EPA), and this fatty acid is known to compete with other fatty acids like linoleic and arachidonic for absorption into the tissue and may result in fatty acid imbalance and altered growth.

Between 20 and 80 milligrams of GLA (gamma-linolenic) acid are needed by the newborn infant each day in order for cell division to take place normally and for cell membrane composition to remain balanced. (32) These levels are provided by human milk, so long as the maternal diet is balanced in terms of fatty acid composition. (33) Infant formulas sold in the U.S. typically contain no GLA, and babies fed such formulas have been shown to have altered phosphoglyceride and sphingomyelin composition in the cell membranes than breastfed babies. (34) For these reasons, approximately 30% of all infant formula sold in Japan contains the added ingredient of evening primrose oil (EPO) - a rich source of GLA at approximately 45-90 milligrams of GLA per gram of EPO.

Micronutrients

In addition to the unique composition of human milk in terms of protein, carbohydrate, and fat is its unique micronutrient, i.e., vitamin and mineral content. For the vitamins, differences include the unusually high concentration of retinyl esters in human milk, making its vitamin A content significantly different from cow's milk; the higher levels of gamma and beta versus alpha tocopherol in human milk; and the preponderance (75%) 25-dihydroxycholecalciferol as the metabolic form of vitamin D delivered to the infant.

For minerals, the most interesting differences involve zinc, iron, and selenium. Virtually all of the selenium in infant formula has traditionally been added to cow's milk in the form of inorganic selenite. In human milk, selenium is found exclusively within selenoproteins like selenomethionine. When supplementing the diet of the nursing mothers or enriching soy formula, however, researchers have found that selenium supplied in the form of selenate appears best able to help maintain activity of selenium-requiring enzymes like glutathione peroxidase (GPO), as well as infant red blood cell levels of selenium. (35)

The mineral zinc has been shown to be twice as absorbable by the infant when provided by human milk than when provided by either infant formula or cow's milk. (36) For iron, the absorption rate from human milk is 50% higher than the absorption rate from formula (37), posssibly due to the presence of inosine 5'-monphosphate in human milk.

**The Body Knows What Its Doing**

What all of these unique features of human milk point to is an intelligence on the part of the human body . The bodies of the nursing infant and the breastfeeding mother know what they are doing. In natural medicine, there is a phrase "vis medicatrix naturae" - the healing power of nature - and this healing power extends to all aspects of human health, including nourishment. Prolonged breastfeeding is health-protective for both mother and infant, and the full-spectrum composition of human milk bears little resemblance to commercial formula or cow's milk. Not yet mentioned in this article are the numerous studies of breast milk composition and the way in which it changes in synchronization with the needs of the child. Even differences between right and left breast milk, fore and hind milk, and morning and evening milk have been show to adapt to the infant's nursing patterns and nutritional needs. The body knows what it's doing. When we add to this picture the research-based links between allergic rhinitis, atopic dermatitis, atopic eczema, bronchial asthma, chronic constipation, colic, juvenile-onset diabetes, SIDS and intake of cow's milk protein, the conclusion should be clear. We should stop identifying formula as an acceptible replacement for human milk, at any age and under any circumstance. We should also start trying to remedy the immunological and gastrointestinal insult that we've created through promotion of formula feeding.

**Footnotes**


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