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Ensuring Nutritive Quality Of Breast Milk

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Breast milk has traditionally been the sheet-anchor of infant nutrition among poor communities in India, as in other developing countries. With the recognition of the unique nutritive value of breast milk, developed countries and affluent sections of populations have also increasingly opted for breast-feeding of their infants. Breast-feeding is now being vigorously promoted by national and international health agencies. It is generally agreed that "exclusive" breast-feeding is to be recommended for six months of infancy and that breast-feeding should be continued thereafter, for as long as possible.

It is, however, unfortunate that campaigns for the "promotion of breast-feeding" have not always gone hand in hand with equally vigorous campaigns for the promotion of maternal nutrition in pregnancy and lactation. It is through attention to the nutrition of the mother during pregnancy and lactation that the nutrient adequacy of breast milk can be ensured. It is apparently being assumed that no matter how poor the maternal diet may be, the mother will be able to deliver milk of the right quality and quantity for the infant. This is clearly a wrong assumption.

Earlier studies: A series of studies on the composition of breast milk of women of poor communities in India, and on the effect of dietary supplementation thereon, had been carried out at the National Institute of Nutrition[1-6] several years ago. Though intensive studies of this kind have not been energetically pursued in recent years, the findings of earlier studies could still be largely relevant and applicable, especially to the poor communities in the country.

Nursing women in poor communities in India with body weights ranging from 35-50 kg generally subsist on diets which provide 1,400-2,200 calories with a protein intake of 27-50 gm, largely derived from plant sources[1]. There is little difference between the diets of women in pre-pregnancy, pregnancy and lactation. The need for additional nutrient intake during pregnancy and lactation, in order to meet the increasing nutritional demands, is generally not recognised by poor communities. Health agencies have also not attempted to vigorously promote information on the need for special diet improvement during pregnancy and lactation.

It is, however, remarkable that even with such poor diets, the average output of breastmilk in women of poor communities has been found to range from 480-570 cc daily for the first six months of lactation, and the average protein intake of infant from breast milk to range from 2g/kg body weight in the first fortnight to 1g/kg body weight in the sixth month[7]. Protein supplements to the mother during lactation did not result in significant improvement in the protein concentration of the milk[4]. Apparently there are metabolic and hormonal adjustments (adaptation) in lactation which lead to more efficient maternal utilisation of dietary energy and proteins. Unfortunately, precise information on this adaptive mechanism has yet to be elucidated.

Lactation failure: It must however be emphasised that there are limits to metabolic and hormonal adaptations. In a situation where maternal diets are highly inadequate, lactation failure is to be expected. In a study[8] carried out by the Nutrition Foundation of India in three major cities and their environs in India, it was disturbing to note that a considerable proportion of mothers in all these cities could not exclusively breast-feed their infants even for four months. The percentage of exclusively breast-fed infants at the end of four months was 66 per cent in Mumbai, 45 per cent in Chennai and 35 per cent in Kolkata. Thus, nearly two-thirds of mothers in Kolkata and one-third in Mumbai were unable to exclusively breast-feed their infants, not for want of trying but because of sheer inadequacy of lactation.

As a result of such poor lactational performance, the use of commercial infant foods was more evident in Kolkata than in Mumbai and Chennai. In the face of severe dietary

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deficiency, women are unable to sustain satisfactory levels of lactation even for the first four months. This is a situation which cannot be corrected by exhortation of the mothers; it can only be corrected by ensuring adequate maternal nutrition during pregnancy and lactation. It is reasonable to assume that it is the infants denied exclusive breast-feeding because of poor nutrition of the mothers that account for a high proportion of the pool of stunted children in the community. This would incidentally show that the major answer to the widespread prevalence of stunting of children lies in improvement of diets of mothers during pregnancy and lactation.

Chemical composition of milk: Earlier studies had shown that with regard to the proximate principles in breast milk, there were no striking differences between the values observed in women of poor Indian communities and those of the affluent countries in other parts of the world[2]. However, the fat content of breast milk of Indian women was found to be somewhat lower than the corresponding values reported for American, Australian and British women[2]. It has been claimed that the level of dietary fat in maternal diet may have an influence on the fat content of breast milk[2]. We will revert to the role of fats and fatty acids in breast milk later in this article.

Micronutrients: It is with regard to the micronutrients that significant differences were found to exist as between the breast milk of women of poor communities and those of the affluent populations. Thus the concentration of vitamin A, vitamin B_1 and vitamin C were found to be significantly lower in breast milk of poor women investigated in India[2]. While vitamin A supplementation had apparently no effect on the vitamin A concentration in breast milk, supplementation with thiamine and ascorbic acid was reflected in a significant increase in concentration of milk[3].

Since these earlier studies were carried out, numerous other chemical constituents in breast milk, which are important for the development of the infants, have been identified. We do not, at present, have any precise information on the concentrations of these nutritional constituents in undernourished mothers. However, with regard to one aspect, namely, essential fatty acids in breast milk, considerable new information has now become available.

ESSENTIAL FATTY ACIDS

The importance of adequate concentration of essential fatty acids of both the n-6 and n-3 series in breast milk is now being increasingly recognised. Mature human breast milk is a good source of essential fatty acids of both the n-6 and n-3 series. A normal well-nourished woman puts forth adequate amounts of these acids needed for her infant in her breast milk (Table 1). In a normal well nourished woman, the fat stores accumulated during pregnancy by themselves could contribute a significant proportion of the essential fatty acids of milk at least during the first three months of lactation[9]. Undernourished women may be expected to have accumulated relatively less fat stores during pregnancy[10,11].There is need for information on the adequacy or otherwise of fatty acids in human milk of undernourished Indian mothers.

A survey carried out in ten Indian states showed that the 'visible' dietary fat intake was below 10 gm daily in rural populations of India[13]. Ghafoorunissa[14] had estimated that, on the basis of the recommendations of the Food and Agriculture Organisation[9], and taking into account the 'invisible' fats contained in Indian diets, an Indian adult would require at least 20 gm of visible fat as oil, as against 10 gm of which is the current intake of most poor rural populations. In the case of pregnant and lactating women, the requirements of total fats and essential fatty acids are higher. The invisible fat of cereals and pulses contained in usual Indian diets can only provide 30-40 per cent of the requirement in pregnancy and lactation. It has therefore been suggested that the intake of visible fats in pregnant and lactating women must be 30 gm and 45 gm, respectively. Dietary intake of fat in case of women of poor communities rarely approaches this level. Thus the intake of fats and fatty acids in lactating women falls far short of the estimated requirement. This could be reflected in poor concentration of essential fatty acids in breast milk. Intensive studies to assess the order of this deficit are extremely important.

TABLE 1
Fatty Acid Content in Mature Human Milk

(%Wt/Wt)	Europe	Africa
Saturated	45.2	53.5
Mono-unsaturated	38.8	28.2
Linoleic acid	11.0	12.0
n-6 derivatives	1.1	1.5
Linolenic acid	0.9	0.8
n-3 derivatives	0.6	0.6

Fat output in milk is variable and depends on maternal nutrition and prolactin secretion. It has been estimated that the mother's diet should provide 3 to 5 g of essential fatty acid daily to ensure adequate concentration of essential fatty acids in milk[12]. In the absence of adequate intake of foods rich in essential fatty acids including fish, green leafy vegetables, pulses and edible oils, essential fatty acids in breast milk could fall short of the requirements for normal infant growth and development. Indeed, the dietary intake of these foods rich in essential fatty acids is currently inadequate in women of poor households.

Role of essential fatty acids in breast milk: The parent essential fatty acids, linoleic acid (LA) and a linolenic acid (ALNA), cannot be synthesised in humans and, therefore, need to be consumed as a part of the diet. The total accretion of essential fatty acids in normal pregnancy is estimated to be around 600 g[15]. In the case of women on poor diets, essential fatty acid accretion of this order during pregnancy will not be possible. The

TABLE 2
Approximate Fatty Acid Composition of Visible Fats (G/100g)

	SFA	MUFA	LA	ALNA	LA/ALNA
Coconut	89	7	2	<0.5	4
Red palm (raw)	50	40	9	<0.5	18
Groundnut	24	50	25	<0.5	50
Rape seed/mustard	8	14	12	10	1
Sesame	15	42	42	1	42
Sunflower	13	27	60	<0.5	120
Safflower	13	17	70	<0.5	140
Soyabean	15	27	53	5	11

SFA: Saturated fatty acid MUFA: Mono-unsaturated fatty acid LA: Linoleic acid
ALNA: Alpha-linolenic acid

essential fatty acids are converted into their desaturated derivatives. The most important derivatives of the n-6 series are dihomogamma linoleic acid (DHGLA) and arachidonic acid (AA) and these are the precursors of the eicosanoids of '1' and '2' series, respectively. The important derivatives of the n-3 series are eicosopentanoic acid (EPA) and docosahexaenoic acid (DHA). During gestation the placenta preferentially selects arachidonic acid (of the n-6 series) and docosahexaenoic acid (DHA) of the n-3 series; and this is reflected in substantially higher proportion of these acids in foetal circulation at mid-term[16] and term[17]. Low levels of arachidonic acid (AA) and docosahexaenoic acid (DHA) are reported in the blood of low-birth-weight newborns[18-21]. Thus infants of the poor, even at the time of their birth, start with a deficit of essential fatty acids. This situation can be expected to get worse in the absence of adequate concentration of essential fatty acids in breast milk.

Neural development: It is estimated that as many as six to 10 thousand synaptic connections between neural cells are forged in the postnatal period and early infancy. The basic materials required for this major operation are the essential fatty acids of human milk. The child's eventual state of mental development may well depend on the adequacy of supply of the needed fatty acids at this crucial stage of development. Almost two-thirds of the structural material of brain is lipid – composed of cholesterol and phosphoglycerides rich in arachidonic acid (AA) and docosahexaenoic acid (DHA). It is, therefore, understandable that dietary supply of essential fatty acids is limiting for brain growth. In the rods of the retina, docosahexaenoic acid (DHA) accounts for 50-60 per cent of the phosphoglycerides embedding rhodopsin and the G-Protein[22,23]. DHA is therefore central to the receptor and neural transmission system on which brain function depends.

Evidence indicates that both n-3 and n-6 fatty acids are limiting for brain growth and that neural integrity can be permanently impaired by deficiency of both n-6 and n-3 essential fatty acids[24-27]. In infants of poor communities, reared on breast milk deficient in these essential fatty acids, it may be expected that neural development could be compromised. The resultant 'mental stunting' could be as important, and indeed even more so, than 'physical stunting', which is receiving wide attention. "Mental stunting" may not be as obvious as physical stunting. But a deficit of even five-10 points in IQ could make all the difference between a child ending up as a "don or a janitor"! It is reasonable to assume that large numbers of poor children in India fail to achieve their full genetic potential not only with respect to physical growth but also, more importantly, with respect to mental development as well because of undernutrition. In this age of Information Revolution, impaired mental development may indeed be of greater consequence than impairment of physical growth from the point of view of the quality of our human resources.

THE SOLUTION

The answer to the problem of deficiency of essential micronutrients, including essential fatty acids in breast milk, does not lie in supplying isolated synthetic nutrients at arbitrary levels. The physiological approach is to improve the diets of women in pregnancy and lactation, using locally available, inexpensive foods, within easy economic reach. Green leafy vegetables such as spinach, amaranth, mint, fenugreek leaves and drumstick leaves are good sources of essential fatty acids, iron/folate and other micronutrients. Pulses such as red gram, green gram, Bengal gram, black gram and lentil, similarly, are also good sources. Legumes, green leafy vegetables and spices contain high proportion of a linolenic acid. Fish oil (from marine sources) is a rich source of essential fatty acids, but apart from some communities in coastal areas, the poor hardly find access to this food. Moreover, a considerable proportion of India's population comprises vegetarians. Poor Indian families have, therefore, largely to rely on vegetable oils.

Vegetable oils: Vegetable oils, used as cooking fat, are the major sources of visible fat in Indian diets. Among edible oils in common use in India, some are rich in essential fatty acids (Table 2). It has been estimated that in order to derive adequate amounts of essential fatty acids, a nursing mother will require about 45 g of edible oil daily[9,28], a level of intake which is hardly attained in poor communities. When any vegetable oil is used as the single source of fat, it does not furnish the ideal polyunsaturated fatty acid (PUFA)-saturated fatty acid (SFA) ratio or the ideal linoleic acid (LA)-α-linolenic acid (ALNA) ratio (n-6:n-3)[9,29-32]. Thus oils such as safflower oil, sunflower oil and soyabean oil furnish high PUFA-SFA ratio, but provide appropriate LA-ALNA ratio. Mustard oil provides considerable amounts of erucic acid, which is not desirable. Erucic acid-free mustard oil is available in the form of canola oil but is currently not available as an Indian product. Coconut oil furnishes low PUFA-SFA ratio and inadequate

levels of EFA. Hydrogenated oils increase the intake of trans fatty acids which is now considered undesirable. In view of these considerations, it may be wise to use oils with moderate levels of LA such as groundnut, rice bran or sesame. Sole dependence on oils rich in LA such as safflower and sunflower may not be desirable; such oils can however, be used in combination with palm oil or mustard oil to increase ALNA.

An additional intake of one ounce of edible oil daily will, incidentally, also provide the much-needed additional energy. The total cost of an additional one ounce of oil, plus a day's allowance of green leafy vegetables and pulse/legumes, would be about Rs 4 (8 US Cents) daily, on the basis of prevailing prices. Except for the abjectly poor, this additional expense towards dietary improvement may be possible in many households. Such dietary improvement will greatly enhance the quality of current household diets, and may also have other spin-off effects such as reducing family expenditure on treatment of illnesses, for which, to a considerable extent, poor households are now depending on private doctors rather than public agencies. Our efforts must be directed towards bringing about improvement in household diets rather than procuring synthetic supplements from abroad and arranging for their (inefficient) distribution by our health agencies (which is, apparently, the current soft option)!

Health personnel are rarely motivated and trained to give advice regarding the ways by which household diets can be improved by using locally available foods at minimal cost; they must now make vigorous efforts to include diet counseling as a major item of their operational agenda. With appropriate and persuasive nutritional education, household diets, even of the poor, can be significantly improved.

Unfortunately, in recent times, vertical programmes designed to combat undernutrition in children have largely failed to provide adequate focus on maternal nutrition during pregnancy and lactation. The "Mother" seems to have receded to the background in the visual field of health agencies (national and international). This situation needs to be corrected; the Mother has to be restored to her rightful place. Maternal and child health (MCH) is a continuum; and our health programmes in future must revert to, and be informed by, the age-old concept of MCH, which implied that both mother and her offspring must have equal focus in public health operations.

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References

1. Gopalan, C.: Studies on lactation in poor Indian communities. *J Trop Pediat,* 4:87-97,1958.

2. Belavady, B., and Gopalan, C.: Chemical composition of human milk in poor Indian women. *Indian J Med Res,* 47:234-245,1959.

3. Belavady, B., and Gopalan, C.: Effect of dietary supplementation on the chemical composition of breast milk in poor Indian women. *Indian J Med Res,* 48:518-523,1960.

4. Belavady, B., Gopalan, C., and Venkatachalam, P.S.: Effect of protein supplementation on creatine concentration of human milk. *Indian J Med Res,* 49:301,1961.

5. Belavady, B., and Gopalan, C.: Nutrition and lactation. *Fed Proc,* 20, p177, 1961.

6. Gopalan, C.: Effect of nutrition on pregnancy and lactation. *Bull Wld Hlth Org,* 26:203-211,1962.

7. Gopalan, C.: Protein intake of breast-fed poor Indian infants. *J Trop Pediat,* 2:89-92,1956.

8. Gopujkar, P.V., Chaudhuri, S.N., Ramaswami, M.A., Gore, M.S. and Gopalan, C.: Infant feeding practices with special reference to the use of commercial infant foods, *Scientific Report 4,* Nutrition Foundation of India, 1984.

9. FAO/WHO Report of an expert consultation. The role of dietary fats and oils in human nutrition. FAO, Rome, 1978.

10. Prema, K.: Pregnancy and lactation. Some nutritional aspects. *Indian J Med Res,* 68 (suppl): 70-79,1978.

11. Delgado, H.L., Lechtic, A., Yarbrough, C., Martorell, R., Klein, R.E. and Irwin, M.: Maternal nutrition, its effect on infant growth and development and birth spacing. In: *Nutrition Impacts on Women;* Eds: Moghiss, K.S. and Evans, T.N., London, Harper and Row, 133-156,1977.

12. Koletzko, B., Thiel, L. and Abiodun, P.O.: The fatty acid composition of human milk in Europe and Africa. *Journal of Pediatrics,* 120(4): S62-S70, 1992.

13. National Nutrition Monitoring Bureau, Report for the year, Section II, Hyderabad, National Institute of Nutrition, 1979.

14. Ghafoorunissa: Fat and fatty acid contents of cereals and pulses and their relevance to Indian diets. *Eur J Clin Nutr,* 43:275-83,1989.

15. Recommendations on energy intakes for pregnancy. WHO, Geneva, 1985.

16. Crawford, M.A., Hassam, A.G., Williams, G. and WhiteHouse, W.: Essential fatty acids and foetal brain growth. *Lancet* (I): 452-453,1976.

17. Olegard, R. and Svennerholm, L.: Fatty acid composition of plasma and red cell phospoglycerides in full term infants and their mothers. *Acta Paediatrica Scandinavica,* 59:637-647,1970.

18. Crawford, M.A., Doyle, W., Drury, P.J., Lennon, A., Costeloc, K. and Leighfield, and M.: n-6 and n-3 fatty acid during early human development. *Jour of Internal medicine,* 225 suppl.1: 159-169,1989.

19. Crawford, M.A., Costeloe, K., Doyle, W., Leighfield, M.J., Lennon, E.A. and Meadows, N.: Potential diagnostic value of the umbilical artery as a definition of neural fatty acid status of the foetus during its growth. *Biochemical Society Transactions,* 18:761-766, 1990.

20. Carlson, S.E., Cooke, R.J., Werkman, S.H. and Tolley, E.A.: First year growth of preterm infants fed standard compared to marine oil n-3 supplemented formula lipids. *Lipids,* 27(110): 901-907,1992.

21. Leaf, A.A., Leighfield, M.J., Casteloe, K.L. and Crawford, M.A.: Factors affecting long-chain polyunsaturated fatty acid composition of plasma choline phospoglycerides in preterm infants. *Jour of Pediatric Gastroenterology and Nutrition,* 14:300-308,1992.

22. Bazan, N.G.: Supply of n-3 polyunsaturated fatty acids and their significance in the central nervous system. In: *Nutrition and the Brain.* Eds: Wurtman, R.J. and Wurtman, J.J., New York. Raven Press, 1-24,1990.

23. Neuringer, M., Anderson, G.J. and Conner, W.E: The essentiality of n-3 fatty acid for the development and function of the retina and brain, *Annual Review of Nutrition* 8:517-541,1988.

24. Bourre, J.M., Domont, O., Piciotti, M., Pascal, G. and Durand G.: Polyunsaturated fatty acids of the omega-3 series and nervous system development .In: *Dietary Omega-3 and Omega-6 Fatty Acids.* Eds: Galli, C., Simopopolous, A.P.159-75,1989.

25. Yamamoto, N., Saitoh, M., Moriuchi, L., Nomura, M. and Okuyama, H.: Effect of dietary alpha-linolenate /linoleate balance on brain lipid composition and learning ability of rats. *J Lipid Res*, 23:144-51,1987.

26. Clausen Moller, J.: Allergic encephalomyelitis induced by brain antigen after deficiency in polyunsaturated fatty acids during myelination. *J Acta Neurol Scand,* 43:375-388,1967.

27. Bazan, N.G.: Supply of n-3 polyunsaturated fatty acids and their significance in the central nervous system. In: *Nutrition and the Brain* Eds: Wurtman R.J. and Wurtman J.J., New York, Raven Press,1990.

28. Ghafoorunissa: Fat and fatty acid contents of cereals and pulses and their relevance to Indian diets. *Eur J Clin Nutr,* 43:275-83,1989.

29. A report of the expert group of the Indian Council of Medical Research. Nutrient requirements and recommended dietary allowances for Indians, Hyderabad, National Institute of Nutrition, 1989.

30. Ghafoorunissa: Fats in Indian diets. *NFI Bull*, Nutr Foundation of India, 10(2): 1-5,1989.

31. Gopalan, C.: Consumption of edible oil in India. The present picture, *NFI Bull,* Nutr Foundation of India, 9:6-8,1988.

32. Indu, M. and Ghafoorunissa: n-3 fatty acid in Indian diets .Comparison of the effects of precursor (alpha-linoleic acid) vs product (long chain n-3 polyunsaturated fatty acids). *Nutr Res,* 12:569-82,1992.