



NFI BULLETIN

Bulletin of the Nutrition Foundation of India

Volume 27 Number 1

April 2006

Essential Fatty Acids in Maternal Diets Beneficial Effects in Pregnancy and Lactation C. Gopalan

Nutritional problems relating to mothers and infants constitute the major challenge to public health agencies in India today. The maternal mortality rate in India stands at 540 (per 100,000 live births). Almost one-third of all live-born infants are of low birth weight (<2.5 kg) and over 50 per cent of under-fives are "stunted"¹.

Low birth weight: Low birth weight is multifactorial in its causation. Short maternal stature, maternal anaemia, low energy intake and low weight gain in pregnancy, infections and smoking have all been identified as possible factors. The gestational age of live-born infants in poor Indian communities appears to be significantly shorter than that reported for the developed countries. As an example, infants born prior to 37 weeks of gestation account for 5 per cent of all births in developed countries (USA² and Norway³) as against 12-14 per cent in India⁴. The incidence of low birth weight even in full term deliveries (>37 weeks of gestation) in India and South Asian countries is much higher than that reported from developed countries⁵. On the other hand, among affluent sections of India the incidence of low birth weight deliveries is apparently of the same order as is observed in the developed countries. For instance, a study⁶ by Nutrition Foundation of India showed that only 6 per cent of infants among the affluent sections of the Indian population were of low birth weight. Thus socioeconomic factors, particularly undernutrition, seem to play the determining role. This situation is especially alarming in the light

of the studies of Barker *et al*⁷ which have revealed that there are long-term implications associated with intra-uterine growth retardation and low birth weight – namely predisposition to chronic degenerative diseases in adulthood.

By far the most common feature associated with low birth weight deliveries in poor communities is maternal undernutrition. Household diets of poor communities are deficient in a wide range of nutrients. It is now well recognised that good maternal nutrition status at the pre-conception and post-conception stages is important for maternal health and foetal development. However, precise information as to the specific nutrients involved in ensuring optimal nutrition in pregnancy, lactation and in infant/child development is lacking, with the result that for several decades now, public health agencies have not been able to make any significant impact on poor pregnancy outcome.

So far, considerable attention has been focused on the effect of supplementation of maternal diets with macronutrients (energy and protein) and some micronutrients (chiefly vitamin A). Today, there is considerable emerging knowledge pointing to the importance of essential fatty acids in ensuring beneficial effects on pregnancy outcome. This has apparently not attracted adequate attention from obstetricians and public health workers in India.

Some bio-chemical aspects of essential fatty acids are presented in the box on page 2. The role of essen-

tial fatty acids in pregnancy and lactation is discussed below.

Pregnancy: There are a number of observations pointing to the beneficial role of essential fatty acids in pregnancy^{8,9}. According to some estimates¹⁰, the average total accretion of essential fatty acids during normal pregnancy in a well-nourished woman amounts to about 600 g. During gestation the placenta preferentially selects arachidonic acid (of the n6 series) and docosahexaenoic acid (DHA) (of the n-3 series); and this is reflected in the substantially higher proportion of these acids in foetal circulation at mid-term¹¹ and term¹². Any beneficial effects that these nutrients may have on birth weight and neonatal development may be denied in varying degrees to preterm infants. Deficits of arachidonic acid and DHA have been reported in the circulation of low birth weight new-borns¹³ and there is also evidence of vascular pathologies in the placenta of low birth weight babies. Essential fatty acid deficiency is believed to contribute to poor vascular growth and consequent rupture and coagulation in

CONTENTS

- | | |
|--|---|
| ● Essential Fatty Acids in Maternal Diets – Beneficial Effects in Pregnancy and Lactation – C. Gopalan | 1 |
| ● Nutrition News | 4 |
| ● Integrated Child Development Services – World Bank Review – Peter Berman | 5 |
| ● Foundation News | 8 |

Essential Fatty acids

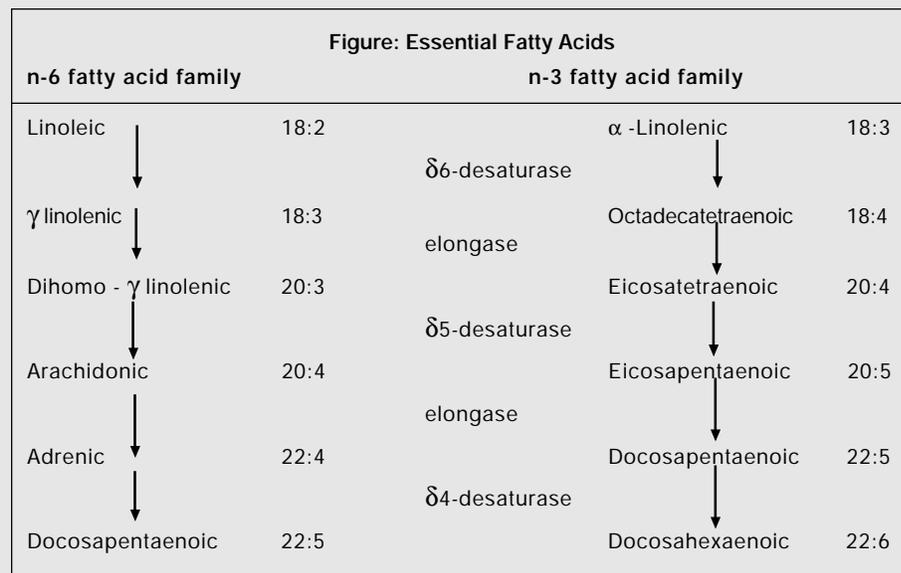
Polyunsaturated fatty acids (PUFA) include the parent essential fatty acids namely linoleic acid LA (n-6) and α -linolenic acid ALNA (n-3) and their long-chain, less saturated derivatives. The parent essential fatty acids LA and ALNA cannot be synthesised in humans and therefore need to be consumed as part of the diet. They are converted into their desaturated derivatives as indicated in the figure. Both n-3 and n-6 fatty acids have common enzymes in their metabolic pathways; n-3 fatty acids usually have higher affinity for the enzymes than the n-6 fatty acids do. The rate-limiting enzyme in the desaturation process is $\delta 6$ desaturase. This enzyme is under the control of many dietary and hormonal factors. The most important PUFA of the n-6 series are dihomogammalinoleic acid (DHGLA) and arachidonic acid (AA) and these are the precursors of the eicosanoids of '1' and '2' series respectively.

The important PUFA of the n-3 series are eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). EPA (to which DHA can be recon-

verted) is the precursor of the eicosanoids of '3' series.

Eicosanoids derived from these precursors are highly active compounds. The eicosanoids cascade consists of (a) cyclic products generated by cyclo-oxygenase – such as prostaglandins, prostacyclin and thromboxane (b) lipoxygenase products such as leukotrienes and (c) products of cytochrome P₄₀₀ activity. AA (of the n-6

series) and EPA (of the n-3 series) compete for the same enzymes, cyclo-oxygenase and lipoxygenases for conversion to eicosanoids (prostaglandins thromboxanes and leukotrienes). Eicosanoids derived from AA and from EPA have opposing metabolic properties. Therefore it is important to ensure a balanced dietary intake of n-6 and n-3 PUFAs.



blood vessels, leading to infarctions in the placenta that are believed to result in impaired placental function and consequent low birth weight¹⁴.

A positive correlation between birth weight and arachidonic acid level in the newborn circulation, as also between duration of gestation and DHA levels have been demonstrated¹³. Reduced levels of arachidonic acid in maternal and cord blood phosphoglycerides are associated with low birth weight and low head circumference of infants, and low placental weight¹⁵. High fish oil intakes by the mother during pregnancy have been shown to be associated with longer gestation and higher birth weight of the infant. Intervention studies with fish oils have also indicated that long-chain n-3 fatty acids have an important role in ensuring normal birth weight^{16,17}. These observations point to the need for ensuring adequate nutritional status with respect to essential fatty acids in the proper proportions during pregnancy, in order to ensure the normal growth and development of the foetus.

Lactation: 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 secretes adequate amounts of these acids in her breast milk as shown in data in Table 1. However, there is need for more information on the adequacy or otherwise of fatty acids in the milk of undernourished mothers. In a normal well-nourished woman the fat-stores accumulated during pregnancy could, by themselves, provide a significant proportion of the essential fatty acids in breast milk at least during the first three months of lactation¹⁸. Undernourished women, however, may be expected to have accumulated relatively less fat-stores during pregnancy¹⁹.

Fat output in human 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 in order to ensure an adequate concentration of essential fatty acids in her milk²⁰. In the absence of adequate intake of foods

rich in essential fatty acids including fish, green leafy vegetables and pulses and some edible oils, the essential fatty acids in the breast milk of undernourished mothers could fall short of the requirements for normal infant growth and development.

Neural development: Almost two-thirds of the structural material of the brain is lipid, composed of cholesterol and phosphoglycerides rich in arachidonic acid and DHA. It is there-

(%Wt/Wt)	Europe	Africa
Saturated	45.2	53.5
Monounsaturated	38.8	28.2
Linoleic Acid	11.0	12.0
Total n-6 LCP*	1.1	1.5
Linolenic Acid	0.9	0.8
Total n-3 LCP*	0.6	0.6
n-3 +n-6 PUFA	13.6	16.6

*LCP - Long chain polyunsaturates

fore understandable that inadequacy of EFA in the maternal diet would be a limiting factor in the brain growth of the infant. In the rods of the retina, DHA accounts for 50-60 per cent of the phosphoglycerides embedding rhodopsin and the G-Protein²¹. DHA therefore plays a crucial role in the receptor and neural transmission system on which brain function depends.

Studies on rhesus monkeys²² subjected to n-3 fatty acid deficiency revealed progressive depletion of docosahexaenoic acid from neural and retinal phospholipids followed by significant impairment of visual acuity, abnormalities in the electroretinogram.

It is estimated that as many as six to 10 thousand synaptic connections between neural cells are made 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. Thus, n-6 and n-3 deficiency during pregnancy leads to intra-uterine growth retardation, affecting the physical growth of the infant; the same deficiencies continuing during lactation further compromise the mental development of the infant as well.

Essential fatty acids in Indian diets

The important question from the point of view of the present discussion is how adequate are the diets of poor pregnant women in India with respect to essential fatty acids. Pioneering studies on the essential fatty acid content of habitual Indian diets have been carried out by Ghafforunissa²³ and Achaya²⁴, and these studies provide a fair picture of the essential fatty acid intakes in Indian diets.

Diets of the poor Indian communities are largely cereal- and pulse-based. Vegetable oil extracted from oil seeds and used as cooking fat is the major source of (visible) fat in the diet. The intake of such vegetable oils hardly exceeds 10 gms per head per day. While in most poor households a single type of oil is used, in some others different types of vegetable oil may be employed depending on the food to be cooked. Apart from vegetable oils other sources of fat like meat and fish

<10	>10
Soya	Safflower
Canola	Sunflower
Mustard	Groundnut
Flax seed	Sesame
Perilla	Ricebran

LA* - Linoleic acids, ALNA** - Alpha linolenic acid, SFA*** - Saturated fatty acids

do not figure largely in the diets of poor households. Moreover, a considerable proportion of the Indian population is vegetarian. Milk intake is also marginal in poor households. All this may suggest that the intake of the essential fatty acids is extremely inadequate in poor Indian diets.

The major components of the Indian diet like cereals, pulses, tubers and vegetables are good sources of invisible fat (meaning fat, which is an integral part of grain). Invisible fat, no doubt is a good source of LA and ALNA. However invisible fat meets only a part of the essential fatty acid requirement. Edible oils with desirable levels of n-3 fatty acids and a proper balance of n-6: n-3 fatty acids would be additionally necessary. Edible vegetable oils vary in their composition of essential fatty acids and in the proportions of n-6; n-3 fatty acids. Oils which do not contain high saturated fatty acids, but have an acceptable level of LA/ALNA ratio are indicated in table 2²⁵. The edible oils which may be expected to meet the essential fatty acid requirements and which also ensure a proper LA/ALNA ratio while being low in saturated fatty acids are soyabean oil, mustard oil and canola oil. However mustard oil contains the

undesirable constituent, erucic acid. Soya oil would, therefore, appear to qualify best as a supplement to maternal diets in pregnancy and lactation.

Ghafforunissa²³ had also computed that over and above the invisible fat present in the diet an intake of edible vegetable oil of the order of 30 gm in pregnancy and 45 gm in lactation would be necessary to fully meet the requirements.

Studies at Nutrition Foundation of India: A study designed to identify a feasible strategy to combat the low birth weight problem by supplementing maternal diets with essential fatty acids was undertaken by the Nutrition Foundation of India²⁶. The study comprised of three groups of pregnant women (n=954) of poor socioeconomic status attending government antenatal centres:

Group 1 (n=317) was the control group, which received routine antenatal care.

Group 2 (n=318) received supervised daily oral supplementation of iron (100 mg) and folic acid (500 mg), starting from the 20th week of gestation.

Group 3 (n=319) received supervised daily oral supplementation of soya oil (equivalent to 900 mg of alpha linolenic acid) starting from the 22nd week of gestation in addition to iron and folic acid supplementation from the 20th week of gestation.

The study indicated that the overall mean birth weight of babies born to mothers in Group 3 was significantly higher compared to both Group 1 and Group 2 and there was a significant reduction in overall incidence of low birth weight deliveries in Group 3 as compared to both Group 1 and Group 2 (Table 3).

Groups	1	2	3
LBW (<2.5 Kg)	21.7% n=69 ^a	21.7% n=69 ^a	14.5% n=46 ^b
Mean Birth Weight (gm±SD)	2735.5 ^a ±386	2766 ^a ±456	2893 ^b ±471

Group 1 - Control, Group 2 - IFA, Group 3 - Soya + IFA
SD - Standard Deviation
Variation in superscripts (within a row) for a given variable indicates significant difference between groups.

The observations of this study are in line with observations in other parts of the world^{16,17}. However there is a need for more studies of this kind in order to firmly establish the role of essential fatty acids in pregnancy outcome. Olsen *et al* found that n-3 fatty acid supplementation using fish oil in the third trimester of pregnancy prolonged pregnancy without any detrimental effect on the growth of the foetus and concluded that dietary n-3 fatty acids prolong gestation and leads to increased birth weights^{16,17}.

The major approach towards combating low birth weight among undernourished populations may lie in the promotion of dietary diversification resulting in the increased intake of green leafy vegetables, pulses and appropriate vegetable oils which are good sources of essential fatty acids. Since the current intakes of these food items in poor Indian diets is neither adequate nor balanced, the short-term approach towards combating low birth weight in poor communities may lie in advising and actively promoting an intake of 15-30 mL of soya oil daily for pregnant and lactating women. The great merit of this approach lies in the fact that soya oil supplementation in the level recommended, may well be beneficial and will most certainly not be harmful. It is also in line with traditional dietary habits and within the economic reach of the poor.

The approach of supplementation of maternal diets with soya oil in pregnancy and lactation (along with the present programme of supplementation with iron and folic acid in the last 100 days of pregnancy) could well become public health policy in the management of pregnancy; and may help to achieve a significant impact on the problem of low birth weight and poor pregnancy outcomes in poor communities.

The author is President, Nutrition Foundation of India.

References

1. The State of the World's Children, UNICEF, 2001.
2. Babson, S.G., Behrman, E., Lessel, R.: Live born birth weights for gestational age of white middle class infants. *Pediatrics*, 45:937-42,1970.
3. Bjerkedahl, T., Bakketeig, L., Lehmann, E.H.: Percentiles of birth weights of single live births at

different gestational periods. *Acta Paediatr Scand*, 62:449-54,1973.

4. Bhargava, S.K., Singh, K.K., Saxena, B.N.: A national collaborative study of identification of high risk families, mothers and outcome of their offsprings with particular reference to the problem of maternal nutrition, low birth weight, perinatal and infant morbidity and mortality in rural and urban slum communities. A task force study. New Delhi, Indian Council of Medical Research, 1990.
5. World Health Organization: Low birth weight. A tabulation of available information. WHO/MCH/92.2. Geneva, World Health Organization, 1992.
6. Sharma, A.: Low birth weight in Indian infants. *NFI Bull*, 22(4), 8, 2001.
7. Barker, D.J.: Intra-uterine growth retardation and adult disease. *Curr Obstet, Gynecol*, 3:200-206, 1993.
8. Allen, K.G., Harris, M.A.: The role of n-3 fatty acids in gestation and parturition. *Exp Biol Med* (Maywood), 226(6): 498-506, 2001.
9. Hornstra, G., Ac, m., Van Houwelingen, A., Foreman van dronegelen, M.: Essential fatty acids in pregnancy and early human development. *Euro J of Obstet and Gynecol and Reprod Biology*, 61:57-62, 1995.
10. Recommendations on energy intakes for pregnancy. WHO, Geneva, 1985.
11. Crawford, M.A., Hassam, A.G., Williams, G., White House, W.: Essential fatty acids and foetal brain growth. *Lancet (I)*: 452-453,1976.
12. Olegard, R., Svennerholm, L.: Fatty acid composition of plasma and red cell phosphoglycerides in full term infants and their mothers. *Acta Paediatrica Scandinavica*, 59:637-647, 1970.
13. Crawford, M.A., Doyle, W., Drury, P.J., Lennon, A., Costeloc, K., Leighfield, M.: n-6 and n-3 fatty acid during early human development. *Journal of Internal Medicine*, 225 suppl.1: 159-169,1989.
14. Althabe, O., Laberre, C., Telenta, M.: Maternal vascular lesions in placentae of small for gestational age infants. *Placenta*, 6:265-276,1985.
15. Doyle, W., Crawford, M.A., *et al*: Maternal nutrient intake and birth weight. *Hum Nutr Dietet*, 2:407-414,1989.
16. Olsen, S.F., Sorensen, J.D., Secher, N.J., Hildegaard, M., Henriksen, T.B., Hansen, H.S., Grant, A.: Randomised controlled effect of fish oil supplementation on pregnancy duration. *Lancet*, Apr 25, 339(8800): 1003-1007,1992.
17. Olsen, S.F., Hansen, H.S., Sorensen, J.D., Jensen, B., Secher, N.J., Sommer, S., Knudsen L.B.: Intake of marine fat, rich in (n-3) polyunsaturated fatty acids, may increase birth weight by prolonging gestation. *Lancet*, Aug 16, 2(8503): 367-9,1986.
18. FAO/WHO Report of an expert consultation. The role of dietary fats and oils in human nutrition. FAO, Rome, 1978.
19. Prema, K.: Pregnancy and lactation. Some nutritional aspects. *Indian Journal of Medical Research*, 68 (suppl):70-79,1978.
20. Koletzko, B., Thief, L., Abiodun, P.O.: The fatty acid composition of human milk in Europe and Africa. *Journal of Pediatrics*, 120(4): S62-S70, 1992.
21. Bazan, N.G.: Supply of n-3 polyunsaturated fatty acids and their significance in the central nervous system. In: Wurtman, R.J., Wurtman, J.J.,

eds. *Nutrition and the Brain*. New York. Raven Press, 1-24,1990.

22. Neuringer, M.D., Connor, W.E., VanPetter, C., Barstad, L.: Dietary omega-3 fatty acids deficiency and visual loss in infant rhesus monkeys. *J Clin Invest*, 73:272-6,1984.
23. Ghafoorunissa.: Fat and fatty acid content of cereals and pulses and their relevance to Indian diets. *Eur J Clin Nutr*, 43:275-283, 1989.
24. Achaya, K.T.: Fat status in Indians – a review. *J Sc Ind Res*, 46:112-26, 1987.
25. Gopalan C., Rama Sastri, B V and Balasubramanian, S.C.: Nutritive value of Indian foods, National Institute of Nutrition, Indian Council of Medical Research, Hyderabad.
26. Gopalan, S., Ganesh, K., Patnaik, R.: Feasible strategies to combat low birth weight and intra-uterine growth retardation. *Journal of Pediatric Gastroenterology and Nutrition*, Vol 39, S 37, Supplement 1, 2004.

NUTRITION NEWS

Lectures

- Dr Prema Ramachandran, Director, Nutrition Foundation of India:
 1. "Micronutrient deficiencies in India – current status and interventions" at the Joint India Bio-fortification-Harvest Plus meeting on "Crop Biofortification for Alleviating Micronutrient Malnutrition"; organised on February 14 and 15, 2006 at M S Swaminathan Research Foundation, Chennai.
 2. "Child nutrition" at "National Consultation on Children in India: Priorities for 11th Plan" organised by the Planning Commission, UNICEF and the Institute of Human Development on January 18 and 19, 2006.
- Dr Sarath Gopalan, Deputy Director, NFI:
 1. "Medium-chain triglycerides" at the National Paediatric Conference (PEDICON - 2006) held from January 4-9, 2006 in New Delhi.
 2. "Enteral nutrition in the critically-ill patient" in the Symposium on "Evolving Trends in Enteral and Parenteral Nutrition" at Kottayam, Kerala on January 24-25, 2006.
 3. "Hospital-based nutritional intervention in India – practical issues" at the Post-Graduate Training Programme in Nutrition, conducted by NIN, Hyderabad on February 6, 2006.