International Journal of Science and Research (IJSR)
ISSN: 2319-7064
ResearchGate Impact Factor (2018): 0.28 | SJIF (2019): 7.583

DHA and ARA Supplements for Brain and Visual Development in Infants

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Abstract: ***Docosahexaenoic acid (DHA) is necessary for the growth as well as functional development of the brain in infants. DHA is important for maintenance of normal brain function. The DHA in the diet improves learning ability, whereas deficiencies of DHA are associated with deficits in learning and visual development in infants, Dietary Sources of DHA and ARA are abundantly found in nature as well as avialble in the form of fortified foods, beverages and supplements. At low levels in meat and eggs DHA is also present .Major infant brain growth occurs during pregnancy and the first two years of life. During these times, new born baby have the greatest require for Docosahexaenoic Acid (DHA). It is an important nutrients to help brain development. The infants fed formula supplemented with Docosahexaenoic acid (DHA) and Arachidonic Acid (ARA) exhibited improved mental development and as well as better visual acuity.***

Keywords: DHA, (ARA), Dietary source, visual acuity

1. Introduction

Docosahexaenoic acid, or DHA, is a polyunsaturated omega-3 fatty acid (PUFA) found in all over the body. It is a major structural fat found in the brain and eye up to 96% of the total omega-3 fats in the brain and up to 94% of the omega-3 fats in a particular part of the eye, called the retina. The function of DHA in the brain is to help in the transmission of messages by nerve cells and to protect the brain as well as help in maintain the flexibility of the brain. DHA is also a essential membrane component of the photoreceptor cells of the eye and is essential for vision. Arachidonic acid (ARA) is a polyunsaturated fatty acid that plays an important role in brain development of infants. Both these fatty acids docosahexaenoic acid (DHA) and arachidonic acid (ARA) are present in human milk. DHA and ARA Supplements play important roles in the composition and function of human tissues brain and retinal development during pregnancy.

Structure of DHA And ARA

Docosahexaenoic acid (DHA) is a long-chain, highly unsaturated omega-3 (n-3) fatty acid) with 22 carbon atoms in its acyl chain and six double bonds in the cis (Z) configuration. Chemically it can be described as all- cis -4,7,10,13,16,19-docosahexaenoic acid, with the numbers 4, 7, 10, 13, 16 and 19 relating to the carbon atoms inside the acyl chain that bear double bonds while the carboxyl or α-carbon is counted as number 1. As the acyl chain of DHA contains 6 cis double bonds, it becomes highly twisted giving it unique physical properties and ensuing in a completely low melting factor (–44°C).

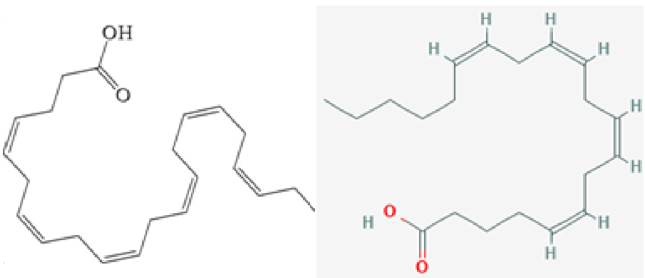

Figure 1: Structure of Docosahexaenoic acid (DHA) and Arachidonic acid (ARA)

Arachidonic acid (ARA) is a 20-carbon chain fatty acid with four methylene-interrupted cis double bonds, the first with respect to the methyl end (omega, x or n) is located between carbon 6 and Hence, ARA belongs to the omega-6 (n-6) polyunsaturated fatty acids (PUFA), is designated as 20:4x-6, with a biochemical nomenclature of all-cis-5,8,11,14-eicosatetraenoic acid.

Sources of DHA and ARA

Arachidonic acid is mainly found in the flesh of lean red meat and chicken, in egg yolks or milk and DHA are synthesized in abundance by using marine algae and found concentrated in fish and marine oils, specifically the oil compartments of cold water fish. Eggs are also an important source of DHA especially for non-fish eaters.

The Dietary sources of DHA are:

- **Algae:** Some algae is the natural sources of DHA. Some species are Schizochytrium sp., Crypthecodinium cohnii, etc The algae in fishes food chain that makes them a rich source of omega-3s.There are various dietary supplements, foods and beverages produced from algae .
- **Fatty and oily fish:** It is an excellent source of DHA. There are many types of fish are the best sources of fatty acids including a salmon, tuna , herring, mackerel, anchovies, and halibut.
- **Eggs and meats:** DHA is also present at low levels in meat and eggs, but new eggs which is enriched with DHA can contain up to 56mg of DHA per egg.
- **Others products:** It includes DHA fortified foods, beverages and supplements.

The Dietary sources of ARA are:
Red meat, egg yolks, algae, fish oil. It is abundant in the brain, muscles, and liver.

Others supplement products: ARASYN™, X-FACTOR (Arachidonic Acid) etc.

Biosynthesis and metabolism of DHA and ARA

The metabolic pathway is common for both DHA and ARA. Linoleic acid and ALA are transformed into ARA and EPA respectively by means of a chain of desaturation and elongation reactions. The EPA-to-DHA conversion involves elongation of EPA to 24:6(n-3) occurring sequentially, followed by accompanied by using a single b-oxidation process, to yield DHA. Linoleic acid helps inn the synthesis of ARA. Linoleic acid is readily oxidized by using delta 6-desaturase to c-linolenic acid (18:3-n6), Gamma linolenic elongation step to dihomo-c-linolenic acid (20:3-n6) and then it is oxidized with the help of delta-5 desaturase to yield ARA.

Omega -6		Omega -3
Linoleic acid- LA;(18:2 n-6)		Alpha Linoleic acid- α-LA;(18:3 n-3)
↓	*Delta6-desaturase*	↓
Gamma Linoleic acid - (18:3 n-6)		(18:4 n-3)
↓	*Elongase*	↓
Dihomogamma Linolenic acid- (20:3 n-6)		Eicosapentaenoic acid- EPA;(20:5 n-3)
↓	*Delta5-desaturase*	↓
Arachidonic acid- AA;(20:4 n-6)		(22:5 n-3)
↓	*Elongase elongase*	↓
Docosatraenoic acid- (22:4 n-6)		(24:5 n-3)
↓	*Delta6-desaturase*	↓
(24:4 n-6)		(24:6 n-3)
↓	*Beta-oxidation*	↓
(24:5 n-6) ↓ Docosapentaenoic acid- DPA;(22:5 n-6)		Docosahexaenoic acid- DHA;(22:6 n-3)

Figure 2: Biosynthesis of DHA and ARA metabolic pathway

Role in Brain Development

The infants fed formula supplemented with Docosahexaenoic acid (DHA) and Arachidonic Acid (ARA) exhibited improved mental health. DHA omega-3 is found the whole body and these amount of fatty acids transferred from mother to fetus depends on placental function.

The third trimester of development is characterized by a raise of fatty acid in the fetal circulation, in particular docosahexaenoic acid, especially to support brain growth and visual development. The mother's DHA status, as indicated by the composition of fatty acids in the maternal erythrocyte membrane improves with the help of treatment with DHA in the third trimester of the pregnancy.

DHA plays a distinctive role in facilitating some of the fundamental functions of astrocytes in the developing brain. DHA is vital for normal brain development in humans. The consumption of large quantities of sources of DHA has been related with an increase in gestational age and better foetal weight at birth. The effect of DHA on foetal weight and development is connected to its effect on the endothelium. DHA increases the flow of blood through vasodilatation in young adults and increases membrane receptor activity.

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DHA deficiency causes impairment of IQ level and memory.DHA supplements several benefits are found such as motor and neurological development verbal intelligence quotient, language and social behavior.

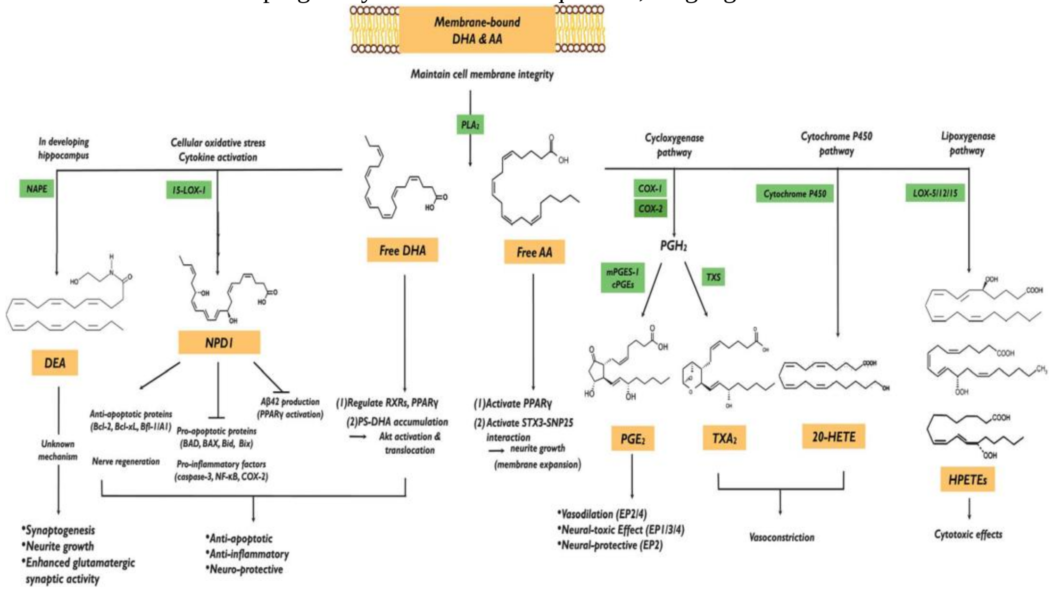

Figure 3: Role of DHA and ARA in brain

ARA is one of the most abundant fatty acids in the brain and main structural components of neural cellular membranes. ARA is vital for brain growth where it plays an important role in cell division and signaling. During development, ARA rapidly accumulates in the brain which takes place from the beginning of the third trimester of gestation up to about 2 years of age.

ARA and LA may be transported across the blood-brain barrier despite its very low content within brain lipids. The brain converts LA to ARA. ARA activity is higher in brain. ARA in found in human milk biologically important because it provides preformed ARA consistently at a time when brain growth and development is most critical. In human milk the majority of ARA derive from maternal stores of ARA.

ARA has several functions in the brain. ARA facilitates neuronal firing signaling and long-term potentiation. ARA also helps maintain membrane order and hippocampal plasticity protects the brain against oxidative stress in the hippocampus by activating the peroxisome proliferator-activated receptor gamma (PPARγ), and helps in the synthesis of new protein in tissue. A potentially essential aspect of ARA metabolism is its function as an immediate precursor for adrenic acid in vivo. Adrenic acid is the third most abundant PUFA in the brain that is found in large amounts in myelin lipids. Rapid accumulation of adrenic acid, like ARA, occurs during the early post-natal period of the brain growth in infants. The conversion of ARA to adrenic acid an important pathway for ARA exploitation. Lower level of ARA in blood causes autism.

Role in Visual Development

DHA and ARA not help only in brain development but these fatty acids also improve visual development. DHA is present in the retina's cells which help in maintaining retinal light–sensitive cells shape and their size by this DHA maintain visual functions. DHA and ARA supplemented formula helps in improvement of visual acuity. The high level of DHA in infant's red blood cells results in visual acuity improved. The neuro-physiological functions are improved like electro-rentinogram, visual evoked potential and visual acuity. DHA supplements with formula at 0.32% of total fatty acids in infants improves visual acuity. DHA is an important constituent of retinal photoreceptors and cortical gray matter. DHA supplementation during pregnancy, help in improvement of visual acuity.

ARA was recommended for management of central nervous system, visual and auditory damage in preterm infants via supporting neurovascular membrane integrity. During the first two years of life, the level of DHA and ARA in the various formulas have a great impacts on visual acuity. DHA influence the visual development of infants. Newborns especially preterm infants have a relatively poorly developed visual system and the visual system undergoes rapid maturation during the first year of life. Supply of appropriate fatty acids in early life has been related to better visual development.

An initial study in 1993 reported that supplementation of marine oil, a rich source of DHA, improved DHA status in preterm infancy and supplemented preterm infants had better visual acuity than the control group at 2 and 4 months of age by an acuity card referential looking test. Supplementation of DHA and ARA improves retinal function assessed by electroretinography and visual evoked potential (VEP). The ability of visual pigment rhodopsin to generate visual nerve impulse depends on retinal lipid composition. The retinal membrane with high concentration of DHA and ARA helps to modulate proper visual signal transduction.

Infant Formula of DHA and ARA

Infants can receive appropriate DHA and ARA intake from breast milk or from DHA- and ARA-supplemented term formulas. Many organizations and foundation have developed different DHA and ARA formula. Most of the formula companies in the United States supplement infant formula with DHA and ARA. Infant formulas typically contain levels of ARA and DHA at 140 mg/day and 100 mg/day, respectfully, based on worldwide averages of ARA and DHA content in human milk Therefore, intakes of ARA and DHA from infant formula are similar to human milk.

	Percent Fatty Acids	
Organization or Foundation	DHA	ARA
British Nutrition Foundation	0.4	0.4
Food and Agricultural Organization of the United Nations/World Health Organization expert panel	0.35	0.7
Expert panel convened by the International Society for the Study of Fatty Acids and Lipids	0.35	0.5

Figure 4: Recommendations for DHA and ARA Supplementation in Infant Formulas by different organizations and foundations

2. Conclusion

The source and supplements of DHA and ARA help in brain and cognitive development, increase learning ability, early language development and evaluated IQ level of infants and adult. For over 10 years, both DHA and ARA have been added to infant formulas worldwide in an attempt to match the nutrient supply and functional benefits achieved with human milk. The combination of ARA and DHA in infant formulas has been shown to be safe in many millions of infants globally. DHA and ARA supplemented formulas also improve retina's cells which result in great improvement of visual acuity and visual-motor function. In conclusion, providing both DHA and ARA supplementing infant formulas supports visual and cognitive development.

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