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Short Communication

Nutritional and Bioactive Components for Cognitive Development: Special Emphasis on Docosahexaenoic Acid (DHA)

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INTRODUCTION

Complete growth and development of various organs and systems and development of cognitive abilities are essential for the health and socio-economic participation of human beings. Nutrition plays a significant role as a non-genetic factor in bestowing physical and mental health to the individuals and this process of attaining nutritional adequacy begins even before the birth of the individual and perhaps even from the time before the conception and pregnancy. Adequate quantitative and qualitative nutrition is essential for overall health status and human productivity. Nutrition also plays a significant role in the development of immunity and conferring resistance to various biotic and environmental stress conditions. Appropriate nutrition can supplement medication in healing and overcoming several diseases and during prophylaxis and aid in the prevention of disease and protection against several non-communicable and chronic diseases and prevention of allergies.

Micronutrients

Iron is essential for energy generation, oxygen transportation, and DNA synthesis. Iron also plays a significant role in hippocampal development, myelination, synthesis of neurotransmitters (dopamine, serotonin, and norepinephrine). Zinc is involved in central nervous system growth and development and is important for neurotransmission. Iodine is the form of thyroxine and triiodothyronine is also important for brain development. Iodine determines the time of differentiation of neural tissue in the brain prenatally and postnatally modulates the number of glial cells for myelin sheath production. Retinoidsare associated with relational memory, synaptic plasticity, learning, memory and sleep, and are essential for normal embryonic development, cell growth, and differentiation

Bioactive components

Nutritional components contribute to the routine growth and development process while the natural bioactive components aid in several important physiological processes such as immunity, hormonal activities, anti-pathogenic activity, enzyme functions, transcription, and translation of proteins and peptides. Bioactive components also have an immense role in the sustainability of health and protection from diseases and associated risk factors. Some of the major bioactive components are α-lactalbumin, lactoferrin, taurine, folic acid, 5-Methyltetrahydrofolate, polyamines, polyunsaturated fatty acids such as docosahexaenoic acid and arachidonic acid, prebiotics, and probiotics [1-4].

The milk protein casein provides amino acids and micronutrients such as calcium, iron, and zinc. β-casomorphins, α-lactorfin, β-lactorfin, albutensin A, β-lactotensin, lactoferricin, and lactoferrampin are the bioactive peptides that are released after digestion of the casein and whey protein. These whey proteins maintain intestinal microflora, facilitate digestion and absorption of nutrients. These peptides including glycans released from glycoproteins exhibit opioid, antimicrobial, and immunomodulatory functions. Human k-casein a 19 kDa glycosylated protein has been shown to prevent the attachment of Helicobacter pylori to the mucosal membrane of human intestine. Phosphopeptides released from casein digestion chelates calcium and enables intestinal absorption of iron and zinc.

Docosahexanoicacid (DHA)

Cognitive development is very essential otherwise; it may affect in the form of behavioral disorders and can affect performance in school, peer- relationships, mental agility, employment and socio-economic activity and productivity. Some of the common behavioral problems o childhoods are attention deficit, hyperactivity disorder, autism spectrum disorder, and anxiety disorder. After conception and by the end of 1000 days the brain grows almost up to 80% of the adult size.Long-chain polyunsaturated fatty acids facilitate the production of neurotransmitters thus affecting monoaminergic, cholinergic, and gamma-aminobutyric acid ergic systems.

Docosahexaenoic acid (DHA, 22:6n−3) is a key omega 3 fatty acid component for neurodevelopment during this phase. DHA is accumulated in neural tissue most rapidly between the last trimesterup to 24 months of age. DHA is a component of phospholipid bilayer of the brain cell membranes and plays important role in membrane fluidity. DHA is the most prominent fatty acid in the cells of the central nervous system including the brain, cerebral cortex, skin and retina.About 40% of the polyunsaturated fatty acids in the brain and 60% of the polyunsaturated fatty acids in the retina is comprised of DHA.

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Almost 50% of the neuronal plasma membrane is composed of DHA. In simple terms, human brain contains more than 50% fat and 25-35% of brain fat is constituted by the essential fatty acid, DHA. Several studies reported that high DHA levels in the pre- and postnatal periods are associated with improved cognitive skills, processing ability, attention, overall IQ up to 12 years.

Main physiological functions of DHA

- Neurogenesis and neuronal development and induction of synaptic growth
- Signal transduction
- Neural transmission (dopaminergic and serotinergic neurotransmission)
- Synaptic functions
- Protection of neural cells from apoptotic death
- Protection against oxidative stress
- Determines the neuron size
- Regulation of nerve growth factor
- Regulation of membrane-bound enzymes
- Regulation of ion channels, potassium channel,
- Development of visual and prefrontal cortex
- Carrier mediated transport of choline, glycine, taurine

DHA is synthesized from alpha linolenic acid or obtained directly from maternal milk. DHA rich food sources are fish and seafood (salmon, mackerel, tuna, herring, and sardines); nuts and seeds (flaxseed, chia seeds, and walnuts); Plant oils (flaxseed oil, soybean oil, and canola oil); eggs, yogurt, milk, soy beverages, infant formulas. DHA can be obtained from different food sources such as cooked salmon (500–1500 mg DHA/100g), caviar (3400 mg DHA per 100 grams), anchovies (1292 mg DHA per 100 grams), cooked herring (1105 mg DHA per 100 grams), mackerel (1195 mg DHA per 100 grams). Other rich sources of DHA are seaweed, nori, spirulina, chlorella, walnuts, and flaxseeds. Flaxseed oil is a rich source of alpha-linolenic acid which is a precursor of DHA. However, the recommended daily allowances for each age-gender and physiological age group need to be followed for deriving their health benefits safely and effectively. About 200 mg/day of DHA is recommended for pregnant and lactating women (National Institutes of Health and International Society for the Study of Fatty Acids and Lipids, NIH/ISSFAL). About 500 mg/day of DHA and EPA is recommended for healthy adults (International Society for the Study of Fatty Acids and Lipids ISSFAL).

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