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Mini Review

Omega-3 Obtained from Oleaginous Microalgae: A Proposal for Vegan and Non-Vegan Pregnancies

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Abstract

This mini-review aims to highlight the important role that omega-3 polyunsaturated fatty acids play during pregnancy, on the fetus and during lactation. These acids are involved in formation of membrane phospholipids in the retina, and grey matter, influencing vision and neurogenesis. The biological role of these fatty acids depends on food intake and supplementation. In this latter aspect, we evaluate the importance of microalgae as a safe source of omega-3 for both vegan and non-vegan diets.

Keywords: Omega-3; Microalgae; Vegan and non-vegan diet; Supplementation; Pregnancy; Lactation; Neurogenesis

Introduction

The World Health Organization (WHO) identifies six essential nutrients: vitamins, minerals, proteins, fats, water, and carbohydrates. Certain fats, mainly monounsaturated and polyunsaturated fats, have notable positive metabolic effects.

Among polyunsaturated fats, long-chain omega-3 fatty acids are especially important. Docosahexaenoic acid (DHA) is a long-chain polyunsaturated fatty acid (LCPUFA) in the omega-3 (n-3) family, featuring a 22-carbon chain and six cis double bonds (22:6n-3) [1]. Although DHA is not considered a strictly essential dietary fatty acid, it can be synthesized to some extent from its essential precursor, alpha-linolenic acid (ALA, 18:3n-3), by desaturation and elongation processes. However, the conversion rate of ALA to eicosapentaenoic acid (EPA, 20:5n-3) and subsequently to DHA is quite low in humans [1,2]. Therefore, DHA levels in plasma and tissues are predominantly influenced by direct dietary intake of DHA. Studies have shown that consuming large amounts of ALA has minimal impact on plasma DHA concentrations [2]. Consequently, numerous organizations worldwide have recommended dietary intake levels for DHA, often in conjunction with EPA intake [3].

Omega-3 Fatty Acids and In-Utero Cognitive Development

DHA quickly builds up in the brain and retina during pregnancy and early infancy and is essential for the infant's growth and maturation. The prenatal period is the most frequently cited as sensitive, during which n-3 LCPUFAs are crucial for neurocognitive development [4]. DHA is found in high concentrations in the phospholipids of neuronal cell membranes, where it can perform many physiological roles, including regulating membrane fluidity,

neurotransmitter release, gene expression, myelination, and cell differentiation and growth [2]. Based on epidemiological studies conducted in regions with high levels of fish consumption, researchers identified a possible correlation between maternal consumption of EPA and DHA and factors such as gestational length and birth weight [5]. During the third trimester, there is an increase in the accumulation of LCPUFAs, primarily DHA, in fetal brain matter at 70 mg per day due to increased cellular synthesis [5,6]. The accumulation of LCPUFAs is significant in the frontal lobe and hippocampus, areas associated with higher-order cognitive functions [7].

In summary, given the biological activity of n-3PUFAs, some researchers have hypothesized that maternal levels influence pregnancy outcomes (gestational age, birth weight, postpartum depression) and fetal development (cognitive and immune function) [8,9]. The findings from various observational and interventional studies are detailed in the latest scientific publications [10,11].

DHA Intake: Diet and Supplementation

Given the low rate of de novo synthesis of DHA from ALA, many organizations agree that DHA is necessary for the maternal/infant diet to achieve and maintain adequate DHA levels in the brain and retina to support their functions in the infant [2,3]. Although recent systematic reviews and meta-analyses have not consistently reported a beneficial effect of higher DHA intake on cognitive and visual function in the early years of life, most have reported a beneficial effect on gestational length and infant birth weight [2]. Most evidence on the health benefits of n-3 LCPUFAs is based on studies on fish consumption and/or fish oil supplementation that contain both EPA and DHA in varying proportions. Seafood and fish are the main dietary sources of DHA, especially cold-water fatty fish, such as salmon, herring, tuna, mackerel, anchovies, and sardines [2]. Breast milk also naturally contains DHA, and its concentration increases with higher maternal intakes of EPA and DHA [12], while most infant formulas are fortified with DHA to support brain development. On the other hand, many supplements are on the market, including fish oil, krill oil, cod liver oil, and other types of parenteral supplements, such as those intended for nutrition in premature newborns [13-15].

At this point, we encounter two issues regarding the intake of polyunsaturated fatty acids during pregnancy, whether through diet or supplements: one is related to pregnant women who follow vegan or vegetarian diets and do not include fish as food [16,17]. The other, and of great concern, is that these sources are in increasingly short supply due to overfishing and ecosystem loss and tend to be contaminated with heavy metals, particularly mercury, which can vary depending on the geographic region [2,18].

Culture Microalgae: Response to the Problematic Issue

In the last two years, there has been a growing interest in utilizing microorganism-produced DHA and EPA as alternatives to traditional fish oil sources [19-26] Microalgae comprise a very broad group of unicellular microorganisms that live in a wide variety of environments and climates. According to the United Nations Food and Agriculture Organization, microalgae have demonstrated promise as a sustainable alternative source of omega-3 [27].

Microalgae, in addition to be a source of DHA and EPA, possess a wide range of valuable biomolecules and essential nutrients, such as vitamin B6, zinc, and vitamin E. It is important to note that microalgae used for human consumption are cultivated in controlled environments, preventing contamination by many agents, such as mercury. Heterotrophic cultivation, which involves feeding the microalgae with organic carbon sources, can generate higher n-3 PUFA productivity compared to autotrophic systems, which rely on photosynthesis, and other systems such as fungal or bacterial, thanks to controlled growth conditions giving higher lipid accumulation as a result. Marine microalgae excel in PUFA production compared to freshwater species [28].

Among oleaginous microalgae most promising for n-3 PUFA oil production due to their rapid growth are Thraustochytrids, marine unicellular heterotrophic microorganisms that can be divided into ten genera, including *Schizochytrium*. Presently, thraustochytrids are preferred in scientific research and DHA commercial production due to their high lipid content (>50% of dry weight) and ease of cultivation [29]. Other species are also promising for n-3 PUFAs oil production, with significant research focused on *Phaeodactylum tricornutum* and *Nannochloropsis* oceanica [30-31].

Microalgae strains frequently consumed by humans are classified as Generally Regarded as Safe (GRAS) by the US Food and Drug Administration [32]. Recent evaluations and assays have confirmed the nontoxic properties of DHA-rich microalgae oil. Consequently, results from ex-vivo and in-vivo studies suggest that this oil is safe for incorporation into novel foods and suitable for infants, adults, pregnant women, and children's formulas. [33,34].

Conclusion

This mini-review provides information on the importance of omega-3 fatty acids during essential stages of life, such as intrauterine and birth. Many authors agree that both the intake and supplementation of high-quality and safe fats are vital for brain development, although the need for further research to better understand the mechanisms of action of essential fatty acids and their potential health benefits is emphasized.

In particular, vegan diets are gaining acceptance worldwide. Nutrient intake during pregnancy makes it essential to have a healthy eating routine. While a carefully planned vegan diet may contain all essential nutrients, some micronutrients need special attention, requiring high-quality and safe supplementation, such as oleaginous microalgae.

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Conflict of Interest

None.

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