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# Development and Production of Omega-3 Fatty Acids-Enriched Foods is an Important Dietary Strategy to Improve People's Nutritional and Health Status (英文原文)

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**Abstract:** Both Omega-6 and Omega-3 fatty acids are essential nutrients important for cellular structure and function but cannot be synthesized by the human body and must be obtained from food. These two classes of fatty acids are metabolically and functionally different and antagonistically regulate many physiological and pathological processes. Thus, the relative balance between Omega-6 and Omega-3 fatty acids are critical for good health. However, today's diet contains too much Omega-6 but too little Omega-3, leading to a severe imbalance with a very high Omega-6/Omega-3 ratio (>10) in most people. Many lines of evidence suggest that this imbalance is a key factor contributing to the development of modern chronic diseases. A growing number of studies ranging from laboratory research to clinical trials have shown that balancing the tissue ratio of Omega-6/Omega-3 fatty acids by increasing tissue levels of Omega-3 fatty acids and/or decreasing the content of Omega-6 fatty acids are very beneficial for the prevention and treatment of many life-threating chronic diseases as well as for health promotion of the general public. Therefore, development and production of foods rich in Omega-3-fatty acids should be considered as a key health program to balance essential fat intake and thereby improve the nutritional and health status of all people.

**Key words:** essential fatty acids; Omega-3 fatty acids; Omega-6 fatty acids; Omega-6/Omega-3 ratio; chronic disease; food; dietary fat; cooking oils

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Omega-3 (n-3) fatty acids are a special class of fats with the following characteristics: Structurally, they appear as a long hydrocarbon chain (18 or more carbons), containing three or more (up to six) double bonds. The first double bond occurs on the third carbon atom from the methyl end. These fatty acids are termed “essential” fatty acids because they cannot be produced by the body (animal or human) and must be supplied by the diet for good health. The source of n-3 fatty acids is limited. Unlike other fatty acids, which are widely available in foodstuff, these n-3 fatty acids are primarily found in fatty fish, certain vegetables and nuts. Functionally, n-3 fatty acids can exert a wide range of effects on cell function. In addition to being a source of energy, these fatty acids can act as determinants of the physicochemical properties of cell membranes, as substrates for the production of signaling molecules or functioning mediators, and as modulators in the regulation of gene expression. Therefore, n-3 fatty acids can profoundly affect the physiological activity and pathological process through multiple mechanisms.

The three common Omega-3 fatty acids found in our food are alpha-linolenic acid (ALA), eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). ALA is mainly found in plant food (e.g. vegetable, nuts and seeds), while EPA and DHA primarily exist in marine vertebrates and algae. Although our bodies are capable of converting ALA into EPA and DHA, it is not a very efficient process and the conversion rate is low. Omega-3 fatty acids, particularly DHA, are highly abundant in the brain, heart and retina and are very important for the cellular structure and function of these organs.

The content of n-3 fatty acids in the human diet underwent a dramatic change during evolution and civilization[1-2]. The foods available to our ancestors were quite different from what we eat today. It is believed that the “ancient” foods were rich in n-3 fatty acids and had an equal balance of n-6 to n-3 fatty acids (i.e., n-6/n-3 ratio close to 1:1)[2]. Today, however, the situation is quite different. Modern agriculture with dietary dependence on grains led to an increase in total saturated fatty acids and the n-6 polyunsaturated fatty acids linoleic and arachidonic acids, which are abundant in vegetable oils (e.g., corn oil, sunflower seed oil, soybean oil, safflower oil, etc.) and feed-raised animal meat. In the past century, the industrial revolution, the emergence of agribusiness with processed foods, grain-fattened livestock, and hydrogenation of vegetable fats have all further reduced the content of n-3 fatty acids and increased n-6 fatty acids[2-3]. In fact, most common foods available today in the market contain a large amount of Omega-6, but little or no Omega-3. Consequently, the modern diet in many countries, including China, is deficient in n-3 fatty acids and has too much of n-6 fatty acids, resulting in a n-6/n-3 fatty acid ratio of >10[3-5]. Obviously, this ratio is contradictory to our genetic profile established on a 1:1 ratio. Unfortunately, our body cannot adjust its gene profile in such a short period of time to adopt the new ratio.

The shift in the n-6/n-3 fatty acid ratio might have imposed a greater risk of modern diseases (e.g. obesity, diabetes, cardiovascular disease, cancer, Alzheimer’s, etc.) and thereby created a serious threat to public health[2-3,6]. These two classes of essential fatty acids compete for the same enzymes for biosynthesis and metabolism and have opposing effects on many physiological and pathological processes–including inflammation, gut microbiota, energy metabolism, insulin sensitivity, and lipogenesis–which underlie the development of many chronic diseases[7-8]. (Generally, n-6 fatty acids promote inflammation, whereas n-3 fatty acids have anti-inflammatory properties.[8]) A growing body of evidence from molecular and animal to human levels shows that a high tissue n-6/n-3 fatty acid ratio is associated with increased risk of several major diseases, while balancing or reducing the n-6/n-3 fatty acid ratio can have beneficial effects on numerous clinical problems and reduce the incidence of chronic disease[6-7,9-10]. Our recent studies using a genetic approach (fat-1 and fat-2 transgenic mouse models) also strongly support the notion that a diet high in n-3 and low in n-6 could help prevent or manage many chronic diseases [7,9,11-15]. Therefore, it is my opinion that the imbalance between n-6 and n-3 fatty acids in the human diet is one of the most critical modern nutritional problem, and that balancing or lowering the ratio by reducing Omega-6, while boosting Omega-3 in our diets is a key solution for the management of the prevalent chronic disease we face today.

Omega-3 fatty acids have now become one of the most intensively studied nutrients for its diverse health benefits[16]. Nearly 60 000 scientific research papers have been published so far covering all aspects of Omega-3, from biochemistry to genetic engineering technology, from healthy food to drug, from prenatal and postnatal care to anti-aging effects, showing its extraordinary importance for human health[17]. Among the many health benefits of n-3 fatty acids, their cardioprotective[18], anti-inflammatory[19], anticancer[20] and neuroprotective

effects[21] have been most intensively investigated and more and more conclusive findings are now becoming recognized[22]. Recent studies have also emphasized the importance of n-3 fatty acids, especially EPA and DHA, in brain development and function[23], maternal health[24], obesity management[25], and longevity[26-29]. On this basis, some government health agencies (such as the WHO-AFO, US-NAS, etc.) and scientific organizations (such as ISSFAL, AHA, etc.) have already made recommendations or statements for increased intake of Omega-3 [30], even though the recommended amounts vary greatly and are still subject to change. Given the multiple beneficial effects on all stages of life cycle, Omega-3 fatty acids are now being widely used as healthy foods, dietary supplements as well as therapeutic drugs.

The growing prevalence of life-threatening chronic diseases, including cardiovascular disease, diabetes and cancer, has become a major global health problem. Many countries have experienced a very fast and broad development of these chronic diseases over the last decades. Unfortunately, the incidence of these diseases will only continue to increase in the years to come. It is important to note that: 1) approximately 70%~80% of the factors underlying the initiation and development of these chronic diseases are related to unhealthy diets or imbalanced nutrition; and 2) none of the major chronic diseases can be cured by drugs alone at the present time; rather, many drugs often cause adverse side-effects to patients. Thus, safe and effective health solutions that target the root causes of modern chronic diseases are urgently needed for better prevention and treatment of these health problems. It is plausible that balancing n-6/n-3 fatty acid ratio in our diet and bodies is such a solution.

Therefore, I call for balancing essential fat intake (that is, increasing Omega-3 and reducing Omega-6) as a key global health program, by promoting the development and production of foods rich in n-3 fatty acids. This program will produce many significant social and economic benefits.

From a medical and public health perspective, this initiative can help improve the overall health of all people. Given the fact that n-3 fatty acids are important structural and functional substances of human cells but cannot be synthesized by the human body and that the deficiency of n-3 fatty acids is a key factor underlying the initiation and development of many chronic diseases, n-3 fatty acids are valuable for both health promotion during the whole life cycle (all people regardless of age and sex) and disease management at various stages (prevention, treatment, rehabilitation). Thus, this program (increasing n-3 fatty acid intake) can help not only reduce the morbidity and mortality of chronic diseases, but also enhance the health quality of all people, thereby greatly reducing the global medical burden.

At the standpoint of research and technology, increased demand by the public for Omega-3 food products will drive research and development of new technologies in this field. Some cutting-edge technologies, such as lipidomics, nutrigenomics, genetic engineering (animal and plant genetic modification technology), processing technology of high quality oils, formulation and production technology of novel healthy food, etc. are important to ensure the continuous supply of high-quality Omega-3 oils and produce healthy and delicious food to meet the need of consumers.

At the industrial and socio-economic levels, increased consumption of Omega-3 and thereby the rise of Omega-3 industrial chain will drive the development and transformation of many related industries, including agriculture, animal husbandry, aquaculture, feed industry, food processing, nutrition and diet, health management, etc. Certainly, the increased demand for n-3 food will bring new development opportunities and economic growth points to these industries. As Omega-3 industrial chain covers such a wide range, it can produce an output value of hundreds of billions.

To effectively implement this Omega-3 program at a large scale in any country, in my opinion, a sufficient understanding of the importance and urgency of increasing Omega-3 intake by all levels from government agencies, researchers, entrepreneurs to consumers is crucial. It is noticeable that current practices in food production and processing, which largely determine the availability of nutrients to consumers, have produced many unhealthy foods that require us to make dietary adjustments for good health. Therefore, future agriculture and food production should be conducted based on scientifically sound nutritional guidelines to produce more healthy food for the consumers. Overall, establishing and promoting an “Omega-3 diet program” in any country require the joint efforts of policy makers, researchers, food producers, medical professionals, educators, etc. Through these efforts, I hope that we can achieve the global goal of ‘Healthy Agriculture, Healthy Food, Healthy People’ in the future.

## REFERENCES

See in its Chinese version P44-P45.