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A Short Review: Production of Omega-3 Fatty Acids from Dairy Industry Waste Water

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ABSTRACT
It has been shown that omega-3 polyunsaturated fatty acids (Omega-3 PUFA) are important for human nutrition and health. The human body produces extremely little Omega-3 PUFA. Omega-3 PUFA is frequently acquired from seafood. However, due of worldwide population growth and consumer knowledge of adequate nutrition, the demand for Omega-3 PUFA for human food and aquaculture has outstripped conventional sources, and they are no longer sufficient. The utilisation of microalgae farmed under heterotrophic settings to create Omega-3 PUFA is gaining popularity. The most significant impediment to creating economically feasible manufacturing techniques is the high cost of using glucose as the principal carbon source for growth. The most recent relevant studies provide new avenues for Omega-3 PUFA production. Early research suggests that using volatile fatty acids (VFA) collected from waste streams as a carbon source for microalgae production might be a viable alternative for glucose. The purpose of this article is to highlight the current status of Omega-3 PUFA production, sources, and market demand in order to provide an overview of sustainable sources currently under research as well as existing and projected market trends for Omega-3.
Key word: *OMEGA-3 fatty acid, dairy industry, waste water*

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INTRODUCTION:

The current era of industries and rapid urbanization has led to a massive consumption of the world's freshwater resources. The rate of environmental contamination has risen due to the water pollution brought on by the discharge of hazardous effluent into water bodies. Among the agro-based industries, the dairy industry is one of the ones with the greatest economic significance. India has surpassed all other nations that produce milk to take the top spot, and it is also recognized as one of the main producers of waste water. The Indian dairy industry is thought to produce roughly 275 million tons of waste water & about 110 million tons of milk per year [1].

The term "lipids" refers to a group of organic compounds found in nature that include fats and oils, waxes, triacylglycerol's, phospholipids, glycolipids, sphingolipids, steroids, and a number of others. These molecules are divided into different groups based on their solubility in organic/non-polar solvents like, chloroform, benzeneor acetone and their water insolubility. Similar to oil and fats, lipids are classified as dietary sources of the maximum metabolic energy. Lipids are also recognized to have a significant part in a number of biological processes, including energy storage, cascade cell signaling, plasma membrane structure, and many more.Glycerol, fatty acids, and esters are the primary building blocks of fats and oils. Saturated fatty acids, which lack double bonds and are found in foods like butter, cheese, pork, oil of coconut, and oil of palm, monounsaturated fatty acids, which had 1 double bond, and polyunsaturated fatty acids are the three main types of fatty acids (PUFAs, bear two or more double bonds in their chemical structure, and are found in sunflower seed oils, flax seeds, corn, fishes, oleaginous microbes, etc.). Since the human body is able to produce both saturated and monounsaturated fatty acids, they are both referred to as "non-essential." Contrarily, PUFAs, which are regarded as "vital," must be included in the diet.Due to their role in preserving human health, PUFA are discovered to be particularly significant among them. Numerous human diseases are prevented and treated in large part because to it [2].

Long carbon-containing fatty acid chains with a methyl group at the at one end and a COOH group at another side are what define PUFAs. Their backbones include many double bonds. SFA uptake in excess had shown to have harmful impact, including the development of arteriosclerosis, which is characterized by the thickening or hardening of the arterial walls, angina pectoris, which is chest ache brought on by a blockage of the heart arteries that reduces blood flow to the heart muscles, as well as other problems with blood of circulation in the body.This mostly caused by SFAs' stable nature, which readily solidifies at ambient temperature and makes denaturalization even following the use of warmth or pressure challenging. On the other hand, unsaturated fatty acids, are unstable and not stiffen at room temperature.[3]
The importance of omega-3 PUFA in human nutrition and health is well known. Omega-3 PUFA consumption, levels of blood, and cardiovascular disease mortality are all inversely related, according to epidemiological research conducted on Greenland Inuit in the 1970s and later human investigations (CVD) [3]. Since then, numerous studies have examined how well Omega-3 PUFA work against a range of diseases, such as diabetes, allergies, asthma, macular degeneration, dementia, thrombosis, heart disease, certain cancers, osteoporosis, etc. Omega-3 PUFA are significant as a potential adjuvant therapy for cardiovascular issues associated to COVID-19 and are suggested in therapeutic approaches to avoid the dreaded "cytokine storm" even in the current COVID-19 pandemic [4]."
The metabolic pathways that initiate the phase of inflammation that is resolving are activated by omega-3 PUFA. The primary building blocks for the production of specialized pore solving mediators (SPMs), such as resolvins, maresins, and protections, which prevent the production of proinflammatory cytokines, are eicosatetraenoic acid and docosahexaenoic acid. Omega-6 fatty acids, on the other hand, take part in metabolic processes that promote the creation of inflammatory metabolites. Cellular mediators that promote inflammation, such as leukotrienes and prostaglandins, are produced as a result of this synthesis's primary precursor, arachidonic acid (ARA) [5].
An increase in demand for foods and supplements that can deliver health-promoting ingredients has been seen in recent years as a result of growing knowledge about the impact of nutrition on health. Therefore, more global food production will be necessary, along with increased fish and seafood output. One option is fish farming, which regrettably resulted in price hikes and shortages of these essential base materials due to the rising demand for fish meal and fish oil as aquaculture feedstocks [6].
Therefore, it is essential to look into novel Omega-3 PUFA sources to be employed in fish farming as well as to address the rising demand for these fatty acids for good health by the food, nutraceutical, and pharmaceutical industries. Considering that microalgae are the main key triglyceride manufacturers in aquatic food webs, they provide a possible substitute for fish oil. Some particular microalgae generate long-chain PUFA like EPA and DHA in addition to other high value-added compounds. In order to boost the production of Omega-3 PUFA, several experiments are being conducted to create a sustainable microalgae production [7].

MATERIALS AND METHODS

Reviewers searched nine databases for systematically reviewed articles published between and in English-language peer-reviewed journals 2005 and 2022. Relevant articles were identified by search engines; PubMed, Medline, SCOPUS, CINAHL, PsycINFO, Embase, Elsevier, EBSCOHost, and Google Scholar with the following key words: “OMEGA-3 fatty acid, dairy industry, waste water.”

DISCUSION

Always, there is a continuing hunt for alternative viable sources of n-3 FAs due to the limitations of fish oil manufacturing. Although transgenic plants created by gene-editing techniques in plants have the potential to be sources of n-3 Fat, these processes are extremely costly and time-consuming on a wide scale[8]. Therefore, a more efficient, quicker, and environmentally friendly source of n-3 FAs is required. In order to use such methods, it would be necessary to industrially extract n-3 FAs and microalgal important microbe oils and other possible oleaginous microorganisms. Due to the fact that they are produced by single-celled microbe, these oils of microorganism are also known as single cell oils [9].
Compared to generation from external solar ponds, the level of process control and the sterility attained in complete fermentation process may both improve the quality of food and pharmaceutical manufacturing. The ability of some microalgal species to thrive in heterotrophic environments, with no light and just a little amount of space needed, suggests that they may be grown everywhere in the globe, regardless of climate, making them a possible option to manufacture Omega-3 PUFA. production of heterotrophic algal species. Systems have the ability to produce omega-3 fatty acids at levels that are 2–3 orders of magnitude higher than those of autotrophic synthesis. Furthermore, compared to published productivities for fungal or bacterial systems, microalgal fermentation systems' claimed omega-3 PUFA productivities are between one and two orders of magnitude higher [10].

Microalgae and a select few other microbes are regarded as the main suppliers of n-3 FAs. There are two common pathways for PUFA synthesis: the aerobic pathway, which uses during the desaturation process, molecular oxygen involves the enzymes elongase and desaturase, and the anaerobic pathway, which uses polyketide synthase as the key enzyme and is present in many bacteria and eukaryotic microbes.Both n-3 and n-6 fatty acids, including EPA, DHA, and AA, are found to be abundant in algae oils. Common algal sources of n-3 FAs include thraustochytrids, which are high in DHA, and *Schizochytrium limacinum*, which produces a lot of DHA. Due to the high microbial oil content of this particular genus of algae, throustochytrids, it is frequently used to produce huge quantities of SCO. EPA are mostly found in microalgae, including the diatom *Phaeodactylumtricornutum, Monochrysislutheri, Monodus, and Chrysophyceae* (rich in EPA) [8].

When compared to fungus and microalgae, bacteria are typically not thought of as an effective generator of EFAs. However, it has been demonstrated that several barophilic and psychrophilic marine species, including those belonging to the Shewanella genus, are important PUFA makers.Other bacterial species that are recognized for producing PUFA include *Arthrobacter sp., Acinetobacter calcoaceticus, Rhodococcus opacus,* and the *coccoid Actinobacterium Kocuria sp. BRI 35*, which was isolated from an Antarctic Sea water sample, demonstrated its capacity to produce PUFAs. It is a Gram-positive organism [11].

Due to their benefits over terrestrial crop plants, microalgae are regarded as one of the finest good sources of n-3 FAs.Simpler fatty acid compositions and a greater growth rate are some of the identifying characteristics. The extent of the anaerobiotic zones formed in various aquatic systems as a result of oxygen decrease caused by bacterial decomposition of organic waste varies.In contrast to eutrophic systems, which have a high algal content, mesotrophic and oligotrophic systems in water are observed to have deeper levels of this zone.The duration of this zone significantly affects how much starch and/or lipids microalgae accumulate as a means of survival due to the growth-restraining strains brought on by overpopulation (algal bloom development) and a rise in organic matter, eutrophic lakes in particular experience changes in a number of environmental variables, including nutrient deficiency, salinity, temperature, light, UV radiation, and others.Competition for light, food, and other essential resources for survival then ensues as a result of this. Thus, by modifying the growing conditions of these microalgae, n-3 FAs and other lipids may be harvested with ease.*Nannochloropsis sp., Dunaliella sp.* (by adjusting temperature, salinity, and light intensity), *Pavlova lutheri* (by decreasing temperature), and *Crythecodiniumcohnii* ATCC 30556 are some of the organisms that can produce n-3 FAs. When cultured in 9 g l-1, (56.9% of the DHA saturated fatty acid content was discovered to be enhanced). Additionally, studies show that lipid peroxidation is shown to boost PUFA synthesis and that changes in growth circumstances might occasionally result in ROS formation [12].

In order to successfully increase the micro-algal cellular density for a bulk production, the procedure should first be carried out in, hybrid systems, photo-bioreactors, open pondsor even race ways/flow-through systems. Through straightforward processes like centrifugation, filtering, or flocculation, the algae cells are entirely separated from the medium. For improved lipid extraction using organic solvents (often "hexane"), they are further dried. Other methods for enriching PUFAs include molecular sieving (based on membrane permeability and selectivity), vacuum-based molecular/fraction distillation, PUFA transformation (PUFA esterification), extraction of supercritical fluid (supercritical fractionation in CO2), urea complexation (urea and ethanol addition, together with the use of heat, to solubilize fatty acids), and lowering in heat. Additionally, by further processing the micro-algal products, this method has also proven useful in producing biodiesel and charcoal, as well as a variety of nutraceutical and pharmaceutical items made with artificial esters, high value pharmacological chemicals, or precursors.

CONCLUSION

This paper's major goal was to draw attention to the constraints placed on Omega -3 PUFA's original generation, their anticipated demand and market outlooks, and the supply options provided by heterotrophic microalgae. Omega-3 fatty acid productivities in microalgal-based heterotrophic production systems can be many orders of magnitude higher than those in autotrophic production.The expense and environmental effect of the carbon sources that must be employed are the primary obstacles in the utilisation of heterotrophic microalgae to manufacture Omega -3 PUFA. Typically, glucose is employed as a source of carbon, & may account for up to 80% of the overall value of cultivating heterotrophic organisms. This study concentrated on gathering research being done right now to create economically viable methods for producing EPA and DHA. According to recent articles, carbon sources from the renewable side (sugarcane waste, cane molasses, food waste hydrolysates and cane molasses) might bepromising option.Finally, several substrates may be utilised to produce volatile fatty acids (VFAs), including fruit waste, food waste, garden, and vegetable the organic component of solid waste of municipal, and Sludge from a wastewater treatment plant. The purified and concentrated VFA can be employed as a source of carbon for microalgae-based DHA synthesis.

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