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BIOLOGICAL FEATURES, NUTRITIONAL VALUE, AND CULTIVATION PROSPECTS OF THE NITROGEN-FIXING CYANOBACTERIA APHANIZOMENON FLOS-AQUAE: LITERATURE REVIEW

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Abstract

Aphanizomenon flos-aquae (AFA) is an organism belonging to the group of blue-green algae widely distributed in nature. Its nitrogen-fixing properties and its rich composition of biopolymers, especially proteins, are of great importance. This microscopic alga contains 60-70% protein, as well as many minerals and trace elements, and high-value compounds such as C-phycocyanin (C-PC) and β-phenylethylamine (PEA), which possess nutritional properties. Aphanizomenon flos-aquae (AFA) biomass is used as a biologically active food additive in some countries. However, its safety as a food product depends on the product's origin, chemical composition, and the degree of contamination with cyanotoxins such as microcystins. Therefore, when assessing the suitability of APA biomass for human consumption, it is necessary to comply with relevant sanitary and safety requirements. This article discusses the difficulty of collecting Aphanizomenon flos-aqua in natural conditions.

Keywords: Aphanizomenon flos-aquae, trichome, carotene, phycocyanin, peptidoglycan, heterocyst, photobioreactor.

I. Introduction

Many international scientific journals have been consulted to utilize the data provided within the framework of these studies. Due to the large volume of published literature on the cultivation of the studied cyanobacterium *Aphanizomenon flos-aquae* under laboratory and photobioreactor conditions, the extensive scope of ongoing work, and the limited number of references, only a portion of the available literature was selected for this article. Previous studies have conducted experiments on breeding this species. As a result of these studies, optimal parameters (pH, temperature, light, CO2 concentration) and biotic relationships with other species were determined for the normal growth and development of *Aphanizomenon flos-aquae*. Despite this, the optimal parameters necessary for the industrial production of this species have not yet been sufficiently determined.

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Therefore, the optimal conditions for these cyanobacteria in the laboratory are more diverse.

II. Materials and methods.

Several scientific databases, such as Scopus, Web of Science, and Google Scholar, were used to find information about the species *Aphanizomenon flos-aquae* described in this article. Also, almost all the information in the article is based on international scientific articles and abstracts published between 2000 and 2023. Each source used was carefully studied, data on the chemical composition of this species were obtained, and more emphasis was placed on the amount of protein in its composition. Because its protein content is 60-70%, this indicator can be of great importance in the development of the food industry.

III. Results and discussion

3.1. Morphology and nitrogen fixation

Aphanizomenon flos-aquae is composed of long trichomes, i.e., filamentous structures, which fuse together to form fascicles (collections of trichomes) up to 1.5-2 cm long [23] The formation of these fascicles serves as a defense mechanism. For example, an organism called Daphnia pulex is unable to consume the filaments of *Aphanizomenon flos-aquae*, which are more than 1.5 cm long [5]. The trichomes of this species are composed of cylindrical vegetative cells, which are usually of a straight shape and sometimes may be curved [11,12]. Each vegetative cell in trichomes is surrounded by a sturdy cell wall known as a peptidoglycan [24]. An important feature of *Aphanizomenon flos-aquae* is that it forms heterocysts and akinetes (both of which are specialized vegetative cells). Its heterocysts are of great importance.

This is because heterocysts contain the active enzyme nitrogenaze, which can convert free nitrogen from the air into ammonia. This process directly proves the ability of this species to fix free nitrogen. The resulting ammonia subsequently serves to form other nitrogen compounds, including nitrites and nitrates. These bioavailable compounds are used to synthesize essential cell components, such as amino acids and nucleotides [9].

3.2. Ecology and distribution.

Aphanizomenon flos-aquae is found throughout North America, Asia, and Europe, from Portugal and Spain to the Baltic Sea and Scandinavia [24]. To date, the presence of this species has been established in 40 lakes and 17 countries worldwide. This cyanobacteria is mainly found in temperate climate zones located in high latitudes, as it thrives and develops well in the temperature range of 23-29 °C [19, 21]. Nevertheless, this alga, like all cyanobacteria, is an organism with a high degree of adaptability. For example, it is capable of growing freely even in the saline waters of the Baltic Sea [24]. Scientific research has proven that *Aphanizomenon flos-aquae* is resistant to temperatures up to

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approximately 30°C, while its trichomes can survive at temperatures up to 10°C [17, 22]. ° Furthermore, it is resistant to high alkalinity and can grow even at pH=10 [22]. Like most other blue-green algae, it prefers low light intensity. The optimal light intensity for it is approximately 40–60 µmol of photon m−2 s−1 [15].

3.3. Biotic relationships with other cyanobacteria

Aphanizomenon flos-aquae typically cohabits with other blue-green algae. The most common cyanobacteria associated with AFA are species belonging to the genus Microcystis, including *M. aeruginosa, Dolichospermum, and Gloeotrichia echinulata* [1, 6]. Despite this, the main abiotic factors affecting the biotic relationships of these species in ecosystems have not yet been sufficiently studied. Recent scientific studies have identified several important factors that can help explain the seasonal dynamics between AFA and Microcystis. Due to the tolerance of Microcystis Aphanizomenon to high temperatures and light intensity compared to flos-aquae, favorable conditions for Microcystis reproduction arise during warm months [25, 26]. The presence of nutrients in natural water bodies that serve as food for them also directly affects their biotic relationships. In particular, when the phosphorus content in the water is low, Microcystis grows well, as it has a well-developed ability to absorb and store phosphorus. However, because AFA is a nitrogen-absorbing cyanobacteria, it also has the advantage of development in conditions of low nitrogen content in water [6, 26]. Usually, the proliferation of Microcystis in the water body occurs after a decrease in AFA. It is hypothesized that APA is associated with the release of azor, which is biologically assimilated during cell breakdown [20]. This hypothesis was put forward in a study conducted on Lake Dianchi in China. AFA and *M.aeruginosa* were present in this lake together. It is known that the nitrogen content in the lake increased significantly after industrial wastewater was discharged into the lake in 2010. Subsequently, the development of AFA gradually decreased, and its place was taken by the species *M. aeruginosa*. As a result, by 2012, the development of AFA had completely stopped [27]. It is suggested that Microcystis may produce some chemical that prevents APA from proliferating. However, this has not yet been proven experimentally [14]. It has also not yet been established whether external factors, including temperature, cause the natural decrease in AFA development and accelerate the development of Microcystis, i.e., whether there is a positive or negative relationship between them [6]. Most research conducted under laboratory conditions confirms the second hypothesis, namely the hypothesis that there is a negative relationship (mutual competition) between them. Studies have shown that the growth of Microcystis is directly associated with a decrease in the growth of AFA cells [14, 25].

3.4. Chemical composition and nutritional properties

The only strain of AFA in terms of nutritional value and vitamin richness is Klamath AFA, which is of particular importance. It is noted that the protein content in it averages 60-70% [7]. This strain contains a high amount of essential amino acids [18]. Mycosporin-like amino acids in APA possess antioxidant properties and have been found to protect

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DNA from damage [16]. Klamath AFA is a source of 14 different vitamins and 73 trace elements [18]. This alga is an important synthesizer of carotenoids, forming large amounts of xanthophylls such as lutein, echinenone, and canthaxanthin, as well as carotenes such as lycopene and β-carotene [10, 13]. Klamath AFA also contains many fatty acids. In particular, omega-3 is a fatty acid, which accounts for approximately 25% of the total lipid biomass [18]. Additionally, the chlorophyll and phycocyanin pigments in APA possess nutraseutic properties [4]. The physiological effects of C-PC extracts obtained from its composition are of great interest.

3.5. Growing conditions and photobioreactors

There are very few scientific studies on the cultivation of APA in laboratory and photobioreactor conditions. Therefore, its optimal growth conditions have not been fully studied. Although AFA develops well under low light conditions, i.e., 40–60 µmol of photon at m−2 s−1, the maximum 115 µmol of photon can withstand up to m−2 s−1. At higher light, photoinhibition occurs in the AFA, resulting in a decrease in the growth rate of the alga and its death [8]. The optimal pH environment for APA is 7.5, and it partially grows and develops even in pH ranges of 7.1–11 [22]. Growth temperatures vary, and it has been found that it grows faster at a temperature of 26–28°C. It has been found that when CO2 is added to a cultivated culture, its growth rate and biomass increase, but the exact amount of CO2 added has not been established [5]. To cultivate this species, it is recommended to use nutrient media suitable for various cyanobacteria. For example, BG11, CT, AS

The aforementioned indicators were optimal for the cultivation of APA under laboratory conditions. However, these parameters may not be suitable for industrial-scale APA cultivation or require other additional optimizations [3].

In the process of growing APA in a photobioreactor, if there is not even one optimal indicator, the overall productivity can decrease significantly. Because all indicators are inextricably linked. Furthermore, due to its filamentous structure, AFA is relatively delicate and sensitive to shear stresses during mixing [2]. In general, the technological feasibility of growing this cyanobacterium in large quantities is one of the main difficulties. Therefore, it is necessary to conduct more research on optimal cultivation in laboratory and photobioreactor conditions before applying it to industrial production.

4. Conclusion

The biotechnological and commercial significance of the nitrogen-absorbing filamentous cyanobacterium Aphanizomenon flos-aquae (AFA) has not yet been fully studied. For this reason, it is not being used sufficiently. The presence of phycocyanin and high-value omega-3 substances in its composition means it is a promising species not only for the food industry but also for animal feed, the trade of biofertilizers, and aquaculture.

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By growing APA in closed systems, it is possible to obtain biomass rich in several bioactive products. This opens the way for this species to enter new and necessary industrial sectors. These areas include:

• dyes and colorants;

• sunscreens;

• fish oil and aquaculture products;

• pharmaceuticals

Furthermore, by genetically modifying AFA, it is possible to create specific strains adapted for specific purposes with improved commercial properties. This allows for its widespread use.

Despite the above, the conditions for the controlled cultivation of this cyanobacterium and the possibilities of genetic engineering have not yet been fully studied. Therefore, it is extremely important to conduct an in-depth fundamental study of the growth parameters and genetic modification measures of this cyanobacterium before proceeding with its industrial cultivation.

References

1. Aavad JB (1994) Bloom formation of *Gloeotrichia echinulata* and *Aphanizomenon flos-aquae* in a shallow, eutrophic, Danish lake. Hydrobiologia 289:193–197

2. Acien G, Molina-Grima E, Reis A, Torzillo G, Chini Zittelli G, Claudia S, Masojídek J (2017) Photobioreactors for the production of microal gae. In: Gonzalez-Fernandez C, Muñoz R (eds) Microalgae-Based Biofuels and Bioproducts. Woodhead Publishing, Oxford, pp 1–44

3. Acien G, Fernandez-Sevilla JM, Molina-Grima E (2013) Photobioreac tors for the production of microalgae. Rev Env Sci Bio/Technol 12:131–151

4. Benedetti S, Rinalducci S, Benvenuti F, Francogli S, Pagliarani S, Giorgi L, Micheloni M, D'Amici GM, Zolla L, Canestrari F (2006) Puri fication and characterization of phycocyanin from the blue-green alga *Aphanizomenon flos-aquae*. J Chromatogr B 833:12–18

5. Dawidowicz P (1990) The effect of Daphnia on filament length of blue-green algae. Hydrobiologia 191:265–268

6. Eldridge SLC, Wood TM, Echols KR (2012) Spatial and temporal dynamics of cyanotoxins and their relation to other water qual ity variables in Upper Klamath Lake, Oregon, 2007-09. Scientific Investigations Report. Reston, Virginia. pp 1-44

7. Grewe CB, Pulz O (2012) The biotechnology of cyanobacteria. In: Whitton BA (ed) Ecology of Cyanobacteria II: Their Diversity in Space and Time. Springer, Dordrecht, pp 707–739

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8. Gentile JH, Maloney TE (1969) Toxicity and environmental require ments of a strain of *Aphanizomenon flos-aquae* (L.) Ralfs. Can J Microbiol 15:165–173

9. Haselkorn R (1978) Heterocysts. Annu Rev Plant Physiol 29:319–344

10. Hertzberg S, Jensen SL (1966) The carotenoids of blue-green algae— II.: the carotenoids of *Aphanizomenon flos-aquae*. Phytochem istry 5:565–570

11. Komarek, J. (2006) Cyanobacterial taxonomy: current problems and pros pects for the integration of traditional and molecular approaches. Algae 21:349–375

12. Komárek, J. (2013) Cyanoprokaryota: 3rd Part: Heterocystous Genera. In: Büdel B, Gärtner G, Krienitz L, Schagerl M (eds.) Süßwas serflora von Mitteleuropa, Bd. 19 (3). Springer Spektrum, Berlin, 1130 p

13. Krajewska M, Szymczak-Żyła M, Kobos J, Witak M, Kowalewska G (2019) Canthaxanthin in recent sediments as an indicator of heterocystous cyanobacteria in coastal waters. Oceanologia 61:78–88

14. Ma H, Wu Y, Gan N, Zheng L, Li T, Song L (2015) Growth inhibitory effect of Microcystis on *Aphanizomenon flos-aquae* isolated from cyanobac teria bloom in Lake Dianchi, China. Harmful Algae 42:43–51

15. Park H-K, Kwon M-A, Lee H-J, Oh J, Lee S-H, Kim I-S (2018) Molec ular verification of bloom-forming *Aphanizomenon flos-aquae* and their secondary metabolites in the Nakdong River. Int J Envi ron Res Public Health 15:1739

16. Righi V, Parenti F, Schenetti L, Mucci A (2016) Mycosporine-like amino acids and other phytochemicals directly detected by high resolution NMR on Klamath (*Aphanizomenon flos-aquae*) blue green algae. J Ag Food Chem 64:6708–6715

17. Reinl KL, Harris TD, North RL, Almela P, Berger SA, Bizic M, Burnet SH, Grossart H-P, Ibelings BW, Jakobsson E, Knoll LB, Lafran cois BM, Mcelarney Y, Morales-Williams AM, Obertegger U, Ogashawara I, Paule-Mercado MC, Peierls BL, Rusak JA, Sarkar S, Sharma S, Trout-Haney JV, Urrutia-Cordero P, Venkiteswaran JJ, Wain DJ, Warner K, Weyhenmeyer GA, Yokota K (2023) Blooms also like it cold. Limnol Oceanogr Lett 8:546–564

18. Sandgruber F, Gielsdorf A, Baur AC, Schenz B, Müller SM, Schw erdtle T, Stangl GI, Griehl C, Lorkowski S, Dawczynski C (2021) Variability in macro- and micronutrients of 15 com mercially available microalgae powders. Mar Drugs 19:310

19. Tsujimura S, Ishikawa K, Tsukada H (2001) Effect of temperature on growth of the cyanobacterium *Aphanizomenon flos-aquae* in Lake Biwa and Lake Yogo. Phycol Res 49:275–280

20. Yamamoto Y (2009) Environmental factors that determine the occur rence and seasonal dynamics of *Aphanizomenon flos-aquae*. J Limnol 68:122

21. Yamamoto Y, Nakahara H (2009b) Seasonal variations in the mor phology of bloom-forming cyanobacteria in a eutrophic pond. Limnology 10:185–193

22. Yamamoto Y, Nakahara H (2005) The formation and degradation of cyanobacterium *Aphanizomenon flos-aquae* blooms: the importance of pH, water temperature, and day length. Lim nology 6:1–6

Journal of Advances in Drug Research

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www.jadr.co.in

Volume 17, Issue 05 | Received 15.10.2026 | Accepted 19.10.2026 | Online 26.10.2026

23. Carmichael WW, Drapeau C, Anderson DM (2000) Harvesting of Aph anizomenon flos-aquae Ralfs ex Born. & Flah. var. flos-aquae (Cyanobacteria) from Klamath Lake for human dietary use. J Appl Phycol 12:585–595

24. Cirés S, Ballot A (2016) A review of the phylogeny, ecology and toxin production of bloom-forming *Aphanizomenon spp*. and related spe cies within the Nostocales (cyanobacteria). Harmful Algae 54:21–43

25. Wen Q, Xiao P, Li H, Li W, Yu G, Li R (2022) Succession of *Aphanizomenon flos-aquae* and *Microcystis aeruginosa* in direct co culture experiments at different temperatures and biomasses. J Oceanol Limnol 40:1819–1828

26. Wu W, Li G, Li D, Liu Y (2010a) Temperature may be the dominat ing factor on the alternant succession of *Aphanizomenon flos aquae* and *Microcystis aeruginosa* in Dianchi Lake. Fresenius Env Bull Adv Food Sci 19:846–853

27. Wu Y, Li L, Zheng L, Dai G, Ma H, Shan K, Wu H, Zhou Q, Song L (2016) Patterns of succession between bloom-forming cyano bacteria *Aphanizomenon flos-aquae* and Microcystis and related environmental factors in large, shallow Dianchi Lake, China. Hydrobiologia 765:1–13