



QUALITY AND SAFETY OF KLAMATH LAKE BLUE-GREEN ALGAE

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Overview

Klamath Lake Algae (AFA) is a nutritional food supplement which is harvested each summer from Upper Klamath Lake in Klamath Falls, Oregon and consists almost exclusively of the filamentous blue-green algal species *Aphanizomenon flos-aquae* (AFA). AFA is a nutrient dense food rich in vitamins, minerals, essential amino acids, and proteins. The nutritional benefits of Klamath Lake Algae mostly reported are increased energy levels, heightened mental clarity, improved memory and recall, relief of inflammatory conditions and an overall feeling of well-being.

AFA Algae from Upper Klamath Lake is absolutely non-toxic. However, like many other agricultural products, Klamath Lake Algae may contain naturally occurring compounds, microorganisms or by-products of human activity that need to be monitored and controlled. Each batch¹ (lot) of Klamath Lake Algae is subjected to a battery of scientific tests to ensure that the algae consistently meets the highest standards of safety and purity. As a result of these tests, Klamath Lake Algae is one of the purest and safest foods available.

¹ A batch is defined as the algae harvest from one full day (24 hours).

Aphanizomenon flos-aquae in Upper Klamath Lake

To appreciate AFA Algae, one first should consider the unique ecosystem in which the algae “blooms.” Upper Klamath Lake, which covers approximately 125 square miles, has the greatest surface area of any natural water body in Oregon (Gearheart et al. 1995). Numerous springs charged with water filtered through miles of nutrient-rich volcanic soils on the flanks of the Cascade mountains (Gearheart et al. 1995), and six major tributaries, contribute 90% of the annual inflow to the lake (1,527,600 mean acre-feet (1929-1993); Gearheart et al. 1995). Overall, Upper Klamath Lake is described as a very productive eutrophic lake that is marked by high levels of available nutrients and plant life. It is this wealth of nutrients that allows *AFA algae* to grow in such abundance in the wild. Upper Klamath Lake is one of only a few ecosystems which supports the recurrent growth of *AFA* in such abundance.

Historically, Upper Klamath Lake was a highly productive (eutrophic) and diverse ecosystem due to a naturally high inflow of nutrients (Gearheart et al. 1995). Though the term eutrophic is often associated with adverse water quality conditions, in reality, a body of water may be ecologically “healthy” and eutrophic. In their 1967 report, Miller and Tash described a nutrient-rich sediment layer many feet deep in Upper Klamath Lake. They reported that the principal nutrients in Upper Klamath Lake were supplied through natural geological processes in quantities sufficient to maintain dense algal blooms, however they did not include nutrient

loading which resulted from either local or upper watershed non-point sources (mostly poor forestry and agricultural land management; Gearheart et al. 1995). Current information indicates that human activities have increased nutrient loading to the lake over historical background levels (Bortleson and Fretwell 1993; Gearheart et al. 1995). However, much of the current debate centers on the effect of additional nutrients on an already productive environment. Both internal and external nutrient loading can influence nutrient concentrations in the lake (Bortleson and Fretwell 1993) and probably the composition of the planktonic community, however the paucity of long-term scientific data makes it difficult to determine actual causes. Kaffka et al. (1995) remarked that phosphorous concentrations in available studies were above levels that many limnologists think are limiting to algal growth, and concluded that anthropogenic (human) influences in the Basin were of little consequence compared to natural enrichment processes. However, during periods of intense algal blooms in Upper Klamath Lake, dissolved phosphorus concentrations are reduced to levels which are known to be limiting (Gearheart et al. 1995). Other biologists (Gearheart et al. 1995; Bortleson and Fretwell 1993; Kann and Smith 1993; Miller and Tash 1967) have documented increases in productivity and algal growth over the past century. Bortleson and Fretwell (1993) noted that these increases in productivity were detrimental to fish populations and that such productive systems have the potential to increase the magnitude of algal blooms, furthering the detriments to fish. To counteract these potential changes, most Klamath Basin biologists have expressed support for efforts to restore natural conditions through wetland restoration and initiation of appropriate land management practices in the watershed.

Since agricultural and forestry managed land border the Upper Klamath Lake watershed

(although more than 70% of the watershed is in federal ownership), runoff from these activities does enter Upper Klamath Lake. Though questions about the effect of nutrient loading (sometimes technically referred to as “non-point” source pollution) on lake water quality and lake productivity exist, this does not affect the safety and purity of *AFA algae* for human consumption. Although highly charged emotionally and politically, the word “polluted,” in the Upper Klamath Lake ecosystem, describes a condition in which concentrations of dissolved nutrients (phosphorus and nitrogen) have increased to higher than historic levels. These nutrients have subsequently impacted the aquatic community of the lake by enhancing algal growth and by affecting related chemical properties (dissolved oxygen, pH, ammonia, etc.) of the lake water. When Upper Klamath Lake is said to be polluted, the term usually refers to the amount of nutrients present, their influence on algal growth, and the impact of this algal growth on lake’s aquatic life. Upper Klamath Lake water is practically free of contaminants and man made toxicological pollutants. The nutrients which enter Upper Klamath Lake are the same materials which are referred to as fertilizer when found in topsoil (nitrogen and phosphorus compounds). While not recommended for direct human consumption, they are absolutely necessary components of a growing medium for all plant matter, including algae in Upper Klamath Lake. Upper Klamath Lake is for the algae what a rich soil is for any vegetable.

One of the reasons Upper Klamath Lake is sometimes referred to as polluted or believed to be polluted, regardless of its nutrient source, is because of the lake’s incredible bounty of *Aph. flos-aquae*. Such abundant algal growth is customarily associated with pollution. The most observable influence of abundant algal growth is the change in the chemical properties of the water around the blooming algal masses. In the presence of sunlight, algae utilize carbon

dioxide and produce oxygen as a by-product of photosynthesis (the conversion of light energy to chemical energy). Due to the limited solubility of oxygen in water at high temperatures, relatively little oxygen dissolves in the water and the remainder is released into the atmosphere. During the night, however, algae do not photosynthesize but instead consume oxygen and decrease the amount of dissolved oxygen in the water. When the algal bloom declines and cells begin to die, nightly oxygen demand of the remaining algae, combined with oxygen demand of decaying material in the water, can reduce oxygen levels in Upper Klamath Lake to levels which affect the health of aquatic animals. The fluctuation in carbon dioxide in turn drives changes in lake pH which may directly or indirectly influence the health of fish in the area. Given summer conditions and a large algal bloom, water chemistry can change drastically and dissolved oxygen, pH and ammonia may reach levels which can directly impact fish species (Monda and Saiki, 1993). If fish are not directly affected, they may be stressed by environmental conditions and their resistance to commonly rejected parasites and diseases reduced. These fish will then congregate in and/or near inflow areas of better water quality, yet their density and stressed condition renders them susceptible to outbreaks of disease and die-offs. In Upper Klamath Lake such fish kills (1971, 1986, 1995) are generally attributed to outbreaks of "Columnaris" disease (Logan and Markle, 1993). These outbreaks have been common in fish hatcheries under crowded, high temperature conditions (Piper et al. 1982), and are caused by a common bacteria which specifically affects fish. Under given circumstances, Columnaris, which is normally under control, may take an explosive course and cause catastrophic losses in one or two days after first appearing (Piper et al. 1982).

While the algal species that is now indirectly associated with these fish kills in Upper

Klamath Lake is *Aph. flos-aquae*, this type of reaction to high temperatures and photosynthetically changed water conditions is not restricted to this time or location or to this species. The first reported fish kill in Upper Klamath Lake was reported by Gilbert in June of 1894 (Logan and Markle 1993). While this mortality may have been partly a result of post spawning stress, it is also likely that hot calm conditions and the resulting algal blooms could have degraded water conditions and contributed to this occurrence. While this implies that algal blooms in Upper Klamath Lake are natural and occurred before any large-scale anthropogenic activity around the lake, reported fish kills seem to have increased in frequency through time. Summer fish kills have also occurred in numerous nutrient rich lakes in Canada (Barica 1975). In an effort to assist recovery of diminished native Upper Klamath Lake fish stocks, extensive cooperative work between local environmental agencies has been initiated to explore and enact actions which will ultimately ameliorate conditions which result in these fish kills.

REFERENCES

- Barica, J. 1975. Summerkill risk in prairie ponds and possibilities of its prediction. *Journal Fisheries Research Board of Canada*. Vol 32, pp. 1283-1288.
- Bortleson G.C., and M.O. Fretwell. 1993. A review of possible causes of nutrient enrichment and decline of endangered sucker populations in the Upper Klamath Lake, Oregon. U.S.G.S. Water-Resources Investigations Report 93-4087, p. 24.
- Gearheart, R.A., J.K Anderson, M.G. Forbes, M. Osburn, and D. Oros. 1995. Watershed strategies for improving water quality in Upper Klamath Lake, Oregon. Humboldt State University, Environmental Resources Engineering Department. 3 Volumes.
- Kaffka, S.R., Lu, T.X., and H.L. Carlson. 1995. An assessment of the effects of agriculture on water quality in the Tule lake Region of California. Research Progress Report 108. Univ. Of California. p. 85.
- Kann, J. and V.H. Smith. 1993. Chlorophyll as a predictor of elevated pH in a hypertrophic Lake: Estimating the probability of exceeding critical values for fish success. Klamath Tribes Research Report: KT-93-02. The Klamath Tribes, Chiloquin, Oregon. p. 22.
- Logan, D.J., and D.F. Markle 1993. Fish faunal survey of Agency Lake and northern Upper Klamath Lake, Oregon. *In* Environmental research in the Klamath Basin, Oregon - 1992 Annual Report. S.G. Campbell (ed.) p. 341.
- Matsunaga, S., Moore, R.E., Niernezura, W.P., and W.W. Carmichael. 1989. Anatoxin-a(s) a potent anticholinesterase from *Anabaena flos-aquae*, *J. Amer. Chem. Soc.*, vol. 111, pp. 8021-8023.
- Miller, W.F, and J.C. Tash. 1967. Interim report: Upper Klamath Lake Studies, Oregon, Federal Water Pollution Control Administration. p. 37.
- Monda, D.P. and M.K. Saiki. 1993. Tolerance of Juvenile Lost River and Shortnose suckers to high pH, ammonia concentration, and temperature, and to low dissolved oxygen concentration. *In* Environmental research in the Klamath Basin, Oregon - 1992 Annual Report. S.G. Campbell (ed.) p. 341.
- Oshima, Y., Sugino, K., and T. Yasumoto. 1989. Latest advances in HPLC analysis of paralytic shellfish toxins. *In*: Mycotoxins and phycotoxins, Natoris, S., Hashimoto, K., and Ueno, T. [Eds], Elsevier, New York, pp. 319-326.
- Piper, R.G, I.B. McElwain, L.E. Orme, J.P. McCraren, L.G. Fowler, and J.R. Leonard. 1982. Fish Hatchery Management. U.S. Department of the Interior, Fish and Wildlife Service. Washington D.C. p. 517.