

Highlighting PQQ Research

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A limited number of biological substances are classified as vitamins, and it has been nearly a century since any new vitamins have been discovered. Consequently, a great deal of interest was generated in 2003 when researchers suggested that pyrroloquinoline quinone (PQQ) may qualify as a newcomer to the B group of vitamins.¹ In fact, animal research has since demonstrated that PQQ participates in a range of biological functions with apparent survival benefits, and that PQQ supplementation may also provide benefits related to cognitive, energy metabolism, immune and antioxidant functions, as well as help protect against cardiac ischemic events.²

PQQ Background

In 1979, PQQ was identified as a cofactor in enzymes of several prokaryotic organisms^{3,4}, as well as being essential for the growth of some microorganisms.⁵ Subsequently, PQQ was reported to be nutritionally important as a vitamin or growth factor in mice.⁶ In 1992, PQQ was found to exist in tissues and body fluids of humans and rats. Other research found that it is present in various foods (including mother's milk⁷) and contributes to the PQQ content in human tissues.⁸ In 2003, PQQ was shown to be an essential cofactor in important, enzyme-catalyzed reduction—oxidation (redox) reactions.⁹ In fact, research suggests that PQQ may

eventually be considered as being vital to life, and there may be benefits associated with improving PQQ status through supplementation.¹⁰

Redox Defined

Redox refers to reactions in the body in which a molecule or atom has lost an electron (oxidation) or gained an electron (reduction). This is the process that generates free radicalation (oxidation) and quenches them with antioxidants (reduction). Redox reactions are also involved in the oxidation of glucose in the human body through a series of complex electron transfer processes, ultimately yielding ATP (the energy "currency" of the body).

In bacteria, PQQ promotes growth and is an important cofactor for dehydrogenase/ oxidoreductase enzymes in bacteria. PQQ is also involved in regulating cellular function and plays a role in the process of signal transduction for cellular growth, development, differentiation and survival.¹¹

Is it a Vitamin?

The jury is still out on whether PQQ is actually a vitamin. Current research has certainly shown that it plays a critical role in mammalian nutrition.^{12,13} Furthermore, when omitted from chemically defined diets, the resulting PQQ deficiency leads to impairment in

growth and compromised immune function, as well as reproductive function.¹⁴ Dr. Michael Murray suggests that "the nutritional requirements of PQQ are probably in line with folic acid and biotin in terms of micrograms per day versus milligrams per day."¹⁵

Cognitive Support

Amyloids are fibrous proteins with improper structures. They erroneously interact with one another or other cell components, resulting in the formation of fibrils (i.e. fine fibers). Amyloids are associated with the pathology of many human diseases, including Alzheimer's disease and other neurodegenerative disorders. In animal research, PQQ was shown to inhibit the amyloid fibril formation of the amyloid protein, beta amyloid (the major amyloid implicated in Alzheimer's) and dramatically inhibit mouse prion protein. The researchers concluded that PQQ has potential to become a leading anti-neurodegenerative compound in the treatment of neurodegenerative diseases.¹⁶

In addition, beta amyloid has been shown to cause neurotoxicity in Alzheimer's disease by evoking a cascade of oxidative damage to neurons. In laboratory research, PQQ was shown to help protect against this type of oxidative damage and subsequent neurotoxicity caused by beta amyloid.¹⁷

In 2007, a human double-blind, placebo-controlled clinical trial¹⁸ was

conducted in Japan using PQQ. Seventy-one subjects between the ages of 40 and 70 years were supplemented with a placebo, with 20 mg of PQQ daily, or with 20 mg of PQQ along with 300 mg of coenzyme Q10 (CoQ10). The results showed improvements on tests of higher cognitive function in the PQQ group compared to the placebo group. In the PQQ + CoQ10 group, results were even greater; this may be a result of the fact that both PQQ and CoQ10 are involved in energy metabolism in the mitochondria.

Energy Metabolism

Mitochondria are the cellular organelles that manufacture the body's energy "currency," ATP. In laboratory research, PQQ was shown to stimulate mitochondrial activity. In fact, PQQ stimulate mitochondrial biogenesis, suggesting that it may be beneficial in diseases associated with mitochondrial dysfunction.¹⁹ Furthermore, research in mice showed that those supplemented with PQQ had 20 to 30 percent more mitochondria than PQQ-deficient mice.²⁰

Immune Support

The importance of PQQ to immune health is evident when it is omitted from chemically defined diets, resulting in compromised immune responsiveness.²¹ Specifically, PQQ deprivation results in a reduction in interleukin-2 (IL-2), a loss of B- and T-cell sensitivity to mitogens.^{22,23} Conversely, oral supplementation of PQQ increases the responsiveness of B- and T-cells to mitogens (chemical substances that encourage a cell to commence cell division).²⁴

Antioxidant Activity

PQQ has been reported to function as an antioxidant and redox modulator in cell culture experiments and in animal models of human diseases. For example, PQQ was an effective antioxidant protecting mitochondria against oxidative stress-induced lipid peroxidation, protein carbonyl formation and inactivation of the mitochondrial respiratory chain.²⁵ In its reduced form, PQQ exerted greater protection than alpha-tocopherol (vitamin E) toward the galvinoxyl and peroxy free radicals, and appeared to have synergistic activity with vitamin E as an antioxidant.²⁶ Additionally, PQQ is capable of carrying out 20,000 catalytic conversions as an antioxidant, compared to only four for vitamin C.^{27,28}

Cardiac Ischemic Protection

PQQ may be helpful when there is insufficient blood flow to the heart (cardiac ischemia)²⁹⁻³¹, and it helps protect against oxidative stress in heart muscle cells.³² The result is less cardiac damage and a reduced incidence of ventricular fibrillation (i.e., abnormal quivering of the heart muscle rather than proper contraction). In animal research, PQQ administration reduced infarct size (i.e., tissue death) in cardiac ischemia, and also protected mitochondria from oxidative damage.³³

Conclusion

Whether it achieves recognition as a vitamin, PQQ is an interesting biochemical with an apparent role to play in human health and wellness. To date, published research has been largely limited to laboratory (*in vitro*) and animal research, with only one unpublished human study cited. PQQ will likely gain more prominence within the scientific community as additional human research is undertaken. **VR**

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