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Can aquaculture help with mineral, vitamin deficiencies?

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A better understanding of culture waters, feeds can help

Salt can be added to freshwater or low-salinity ponds, lined and unlined, to meet the mineral requirements of marine animals able to survive in low salinity (TDS) waters. Photo by Darryl Jory.

Mineral deficiencies in the human diet started with the invention of commercially available electricity in the 1870s. This advance in technology would result in the reduction of the use of wood fires for cooking, decreasing the need for disposal of wood ashes in garden soils.

Wood ash is an excellent fertilizer, as it contains minerals such as calcium that help balance pH and trace elements that aid and support plant growth, contributing to better human nutrition. In addition, widespread damming of rivers and streams to provide for the ever-increasing demand for electricity led to decreased mineral inputs in much of the fertile alluvial soils used.

The late 1960s saw the beginning of modern commercial agriculture that brushed aside organic mineral-rich inputs – such as manures used as a source of nitrogen, phosphorous, potassium and sulfur – in favor of synthetic fertilizers (manufactured from gasses from the air, and various minerals and waste materials) containing no minerals other than these four necessary, major elements. These synthetic nitrate and phosphate fertilizers are water soluble and wash into local streams, creating problems with eutrophication. Modern agriculture is the most widespread contributor to mineral deficiencies in humans in industrialized countries with reduced mineral concentrations in foods produced on mineral-deficient soils.

Modern diets consisting of store-bought, packaged, processed foods and the ubiquitous fast food restaurants remove even more of the little available mineral nutrition from already mineral-deficient foods. Diets of healthy traditional peoples such as aborigines of Australia and native Indian tribes of South America have been determined to contain four times the mineral concentrations of the modern, processed diets consumed in industrialized countries even as far back as the 1930s.

Seafood like oysters have been reported to have the highest concentration of zinc of any natural food. Photo by Darryl Jory.

By 1989, the recommended daily requirements of calcium, magnesium and zinc were not being met by more than 65 percent of the population of the United States. The well-known publication *Scientific American* reported that from 1975 to 1997, calcium in 12 fresh vegetables decreased by 27 percent, with similar findings in the *British Food Journal,* which reported a calcium reduction of 19 percent in 20 vegetables from 1930 to 1980.

Deficiencies were further induced with a lesser amount of whole foods being consumed and more foods of greater appeal, availability and convenience. The taste of fruits and vegetables has often been correlated with the amount of minerals they contain.

Obvious mineral deficiencies in humans can be apparent when considering well-known conditions of anemia, osteoporosis, goiters and stunted growth. However, lesser known correlations have been found between mineral concentrations of diet and water sources, and, increase or decrease in the health of associated populations. More traditional diets of people not exposed to modern agriculture and food processing are known to result in much better dentition than their industrialized counterparts.

The World Health Organization (WHO) has stated that there are 2 billion people in the world suffering from mineral and vitamin deficiencies, with the majority found in developing nations.

Necessary minerals and metabolism in aquaculture

One of the earliest and sometimes most apparent mineral deficiencies known in the U.S. was goiter resulting from a lack of Iodine. This was most prevalent in the Midwest, where soils were lacking this essential mineral. Source: Wikimedia Commons.

Adding salt to manufactured aquafeeds for fish has been documented to improve their growth, by providing the necessary elements for digestion, growth and excretion. In addition, minerals or salt can be added to water to reduce osmoregulatory stress as an aid in transport of various life stages (developing larvae to adult broodstock) of many farmed species, to reduce the number of opportunistic pathogens in the transport water, and to increase growth by reducing the energy required for osmotic balance.

Minerals such as sodium and calcium can be added to the diet or water, which result in fulfilling the mineral dietary requirements for fish culture. Pertinent to absorption, bioavailability and retention of a single mineral provided in the diet of fish may also be determined by the concentration of a metabolically contingent mineral. An example is the relationship between calcium and the bioavailability of zinc. Also, it is unknown how much of the mineral addition to the diet would be maintained in the fish and how much would be lost to the environment during normal osmoregulation and excretion, as measured in total dissolved solids (TDS).

Excretion of nitrogen waste via the gills is the primary, toxic nitrogen removal process in fish, and this is tightly coupled to sodium loss in order to maintain acid-base regulation in the metabolism. This is apparent when examining how the acidity of culture water results in osmoregulatory stress due to decrease in plasma ions of fish in freshwater. Ion transport to maintain salts in the blood of freshwater fish occurs nearly exclusively at the gill surface while fish produce ample volumes of dilute urine.

Minerals, aquaculture and human nutrition

Fish is one of the cheapest sources of protein and minerals available. The mineral concentrations of aquatic animals – whether in excess or deficient – are based on the minerals in the environment, as are other important nutritional compounds such as omega-3 fatty acids and beneficial pigments.

Most of the common minerals needed for maintenance of every biochemical function in humans can be found in fish, while all minerals known can be found in the ocean. The concentrations of minerals in the ocean are near exact proportions of those found in the blood of humans, and in general, minerals in aquatic organisms increase with the salinity (TDS) in the water.

Mineral concentrations in fish vary between species and even between sizes within the same species. Additional variations in mineral content can be found between sections of a fillet. **Research conducted some years ago** (http://www.sciencedirect.com/science/article/pii/S030881460200122X) demonstrated that iron and zinc were two major elements in cultured and wild sea bass with no differences found between the two types in terms of total mineral composition. Zinc has been identified as being deficient in the modern diet in industrialized countries, as previously stated.

The understanding of the mineral content of farmed fish species would benefit greatly by examining the mineral content of waters where these organisms are cultured, the minerals in their diets, and the possibility to increase the mineral content of cultured organisms by manipulating these two variables, or by simply selecting areas with higher mineral content waters for aquaculture development.

References available from author.

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