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"Insight into the Biochemical Link between Biodiversity and Nutraceuticals"

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Abstract: *Human civilization for achieving progress has created a major catastrophe threatening the foundations of biodiversity. Phenomena of industrial development, population explosion, global warming, coupled with the production of non-biodegradable molecules using unsustainable technologies to serve human needs has deteriorated the environment further. The distortion of the delicate ecological balance due to human activities has threatened the survival of biodiversity. Elimination of biodiversity directly questions the survival of our species too in the long run. Thus the need of the hour is to preserve biodiversity, so that its valuable products, like the nutraceuticals are harnessed for the benefit of human life. The article below focuses on the biochemical link between biodiversity and nutraceuticals.*

Keywords: *Biodiversity, Nutraceuticals, Secondary Metabolites*

I. Introduction

Biological diversity or more commonly expressed as the compound term "Biodiversity" means the variability among living organisms from all sources including, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part; this includes diversity within species, between species and of ecosystems. It is the variety of life at every hierarchical level and spatial scale of biological organizations: genes within populations, populations within species, species within communities, communities within landscapes, landscapes within biomes, and biomes within the biosphere.

The increasing use of the term biodiversity is being driven by the fact that, in an ecological context, global biodiversity itself is being lost at an alarming rate. Although it has been shown that the significant global biodiversity loss that has occurred over the timeframe of human existence has not stopped global human population increase, there is clear evidence that biodiversity loss can affect the wellbeing of society and have negative economic impacts. Biodiversity underpins ecosystem function and the provision of ecosystem services. Biodiversity loss therefore threatens the provision of goods and services provided by ecosystems. Reduction in biodiversity can affect decomposition rates, vegetation biomass production and, in the marine environment, affect fish stocks.

In addition to the gradual decline in environmental function linked to reductions in biodiversity, it has been suggested that there is a risk that at some point a threshold will be crossed and a catastrophe may occur. Research has highlighted that biodiversity loss could rival the problems of carbon dioxide increases as one of the major drivers of ecosystem change in the 21st Century. Whether from environmental collapse or gradual decline in function, our ability to adapt to a changing world may be considerably reduced if the environment on which we rely does not contain sufficient biodiversity to evolve and continue to support our needs.

The biochemical variability in biodiversity is usually attributed by Biologists to the phenomenon of Evolution. These diverse changes are likely to have a bearing on and be influenced by the evolutionary forces at play. For an organism or species one of its most primary prerequisites to survival is to remain 'aligned' with its environment; an approach strongly advocated by the Darwinian theory of evolution. Darwinism is a theory of biological evolution developed by Charles Darwin and others, stating that all species of organisms arise and develop through the natural selection of small, inherited variations that increase the individual's ability to compete, survive, and reproduce. Any organism unable to do so, alienates itself from the dynamic environment, thus becomes incapable of survival. This serves as the primary reason behind the mass extinction of species like the Dinosaurs from the surface of the earth. The Darwinian principle centers itself on the concept of 'survival of the fittest' i.e. species inheriting the strongest traits as a result of natural selection are prepared the strongest for survival.

Natural selection in Darwinism usually is manifested in organisms and species as adaptations. Adaptations include physical, sociological, biochemical and molecular traits which enhance survival by improving the equation between the organisms with their corresponding environment. A major breakthrough as

a consequence of molecular and genetic changes as a result of biological evolution is the development of secondary metabolic pathways.

Secondary metabolites are organic compounds that are not directly involved in the normal growth, development, or reproduction of an organism. Unlike primary metabolites, absence of secondary metabolites does not result in immediate death, but rather in long-term impairment of the organism's survivability, fecundity, or aesthetics, or perhaps in no significant change at all. Secondary metabolites are often restricted to a narrow set of species within a phylogenetic; thus are also an indicator of identifying organisms' upto the sub-species level. Secondary metabolites in plants are useful in the later stages of plant life, often for defense purposes, and give plants characteristics such as color. Secondary plant metabolites are also used in signaling and regulation of primary metabolic pathways secondary plant metabolites help the plant maintain an intricate balance with the environment, often adapting to match the environmental needs. There is no fixed, commonly agreed upon system for classifying secondary metabolites. Based on their biosynthetic origins, plant secondary metabolites can be divided into three major groups:

- Flavonoids and allied phenolic and polyphenolic compounds.
- Terpenoids.
- Nitrogen-containing alkaloids and sulphur-containing compounds.

Secondary metabolites in plants are the most widely studied and researched since time immemorial. The principles of early clinical medicine and the system of Ayurveda focused on the treatment of diseases using plant-derived formulations. Through the ages, even though more advanced synthetic pharmaceutical formulations have been developed; natural formulations are gaining importance in today's times. One of the major reasons is that these formulations are easy to extract and standardize, exhibit maximum efficacy in lower concentrations, safe to administer with no adverse side effects (like anaphylaxis or organ failures) even on prolonged administration.

Plant based formulations can be produced using sustainable manufacturing procedures following principles of green chemistry. This means that the per-capita investment of resources and energy is brought to a minimum, which reduces the burden on the environment to provide additional resources for manufacturing. Another advantage is that the formulation ultimately produced is totally biodegradable, thus can be disposed with no environmental harm. The by-products of these manufacturing processes are also biodegradable, but on the plus side are commercially valuable. So, overall one process yields many products with commercial and therapeutic value. Due to all the above reasons, the science of Nutraceuticals has been developed which harnesses the biological efficacy of a secondary metabolite in enhancing the nutritional well-being of an organism and/or exploiting its therapeutic value in combating disease.

The biochemical study of nutraceuticals principles in plant secondary metabolites is focused below. Common plants rich in secondary metabolites used as nutraceuticals include:

1) Deadly nightshade (*Atropa belladonna*): Atropine is a type of secondary metabolite called a tropane alkaloid. Atropine is a competitive muscarinic acetylcholine receptor antagonist. Working as a nonselective muscarinic acetylcholinergic antagonist, atropine increases firing of the sinoatrial node (SA) and conduction through the atrioventricular node (AV) of the heart, opposes the actions of the vagus nerve, blocks acetylcholine receptor sites, and decreases bronchial secretions.

2) Lotus stem, leaf and seed embryo (*Nelumbo nucifera sp*): The rhizome extract has anti-diabetic (Mukherjee et al., 1997a) and anti-inflammatory properties due to presence of asteroidal triterpenoid secondary metabolites (Mukherjee et al., 1997b). Rhizomes are used for pharyngopathy, pectoralgia, spermatorrhoea, leucoderma, small pox, diarrehoea, dysentery and cough. The stem is used in indigenous Ayurvedic medicines as diuretic, anthelmintic and to treat strangury, vomiting, leprosy, skin disease and nervous exhaustion.

Lotus alkaloids dilate the blood vessels and reduce the blood pressure. The embryos within lotus seeds possess an alkaloid isoquinoline, which is sedative, antispasmodic and beneficial to heart. It dispels pathogenic heat from the heart and spontaneous bleeding due to heat. Dauricine and neferine found in the seed block the Na^+, K^+ and Ca^{2+} transmembrane currents in cardiac cells (Qian, 2002). Leaf stalk extract possess antipyretic effect (Sinha et al., 2000), while antioxidants effect is found in leaves and stamen (Jung et al., 2003; Wu et al., 2003). Lotus seed extract possess hepatoprotective, free radical scavenging properties and antifertility properties (Sohn et al., 2003). Gupta et al. (1996) have reported antisteroidogenic effect of seed extract of *N. nucifera* in the testis and ovary of the rat. Liu et al. (2004) reported that the ethanolic extracts of lotus stem inhibit the cell proliferation and cytokines in primary human peripheral blood mononuclear cells activated by phytohemagglutinin (a specific mitogen for T lymphocytes).This shows promise for anti-cancer therapeutics.

Lotus stem extracts could be standardized and developed into formulations, which alleviate the holistic positive effect of lotus stem on human well-being. Summing up, it is indeed true that lotus stem is one of the wonder foods of the plant kingdom.

The findings suggested that lotus stem dip has high organoleptic and consumer acceptability. In addition, the lotus stem dip has high market demand as convenience foods that balance taste with nutrition. The simulated product development exercise concludes further that if the mass-manufacture of such healthy recipes is carried out, there will always be a high consumer demand for such products (Jyoti Vora, et al., August, 2015).

The sensory evaluation involving the semi-trained panelists exhibited high organoleptic acceptability for the product developed from lotus stem viz, Lotus stem milkshake. Also, VFM aspects of the product were evaluated, and the product developed ascertained high VFM (Jyoti Vora, et al., May, 2016).

3) Water hyacinth (*Eichhornia crassipes*): Crude extract of *Eichhornia crassipes* and several fractions showed moderate activities against Gram positive and Gram negative bacteria. It was about 50% as potent as tetracycline. A diversity of antibacterial activities was found attributed to different isolated fractions. Different combinations of these fractions showed similar, slightly lower or higher efficacy compared to the crude extract. Antifungal activities of extracts (crude and different fractions) were manifested only against *C. albicans* (yeast). The DPPH scavenging activity was performed to test the antioxidant properties of the crude extract of *Eichhornia crassipes* and its isolated fractions. The crude extract showed the highest antioxidant activity while some compounds recorded more or less lower or comparable activities. The antioxidant activity of active ingredients separated from *E. crassipes* may be attributed to the presence of hydroxyl group and unsaturated bonds in the chemical structure of its isolated compounds showing high free radicals scavenging ability. Concerning the anticancer activity, the crude extract also showed the highest effect compared to all isolated compounds against several tumor types. Some fractions exhibited selective very potent anticancer activity against liver cancer cell line while other fractions exhibited high anticancer activity against hormone dependent tumor types (cervix and breast cancers). However, further research is required to ascertain this benefit of the water hyacinth.

4) Turmeric (*Curcuma longa*): Numerous reports have suggested that the production of TNF from macrophages activated by various stimuli can be suppressed by curcumin). Studies have supported findings that LPS is one of the major inducers of TNF-α in macrophages and monocytes and that curcumin can down-regulate the expression of TNF-α (Chan, 1995; Abe *et al*., 1999; Jang *et al*., 2001; Gao *et al*., 2004; Strasser *et al*.,2005; Woo *et al*., 2007; Liang *et al*., 2008; 2009; Cheung *et al*., 2009; Jain *et al*.,2009; Nishida *et al*., 2010; Zhao *et al*., 2010). Curcumin is a natural polyphenol molecule derived from the *Curcuma longa* plant which exhibits anticancer, chemo-preventive, chemo- and radio-sensitization properties. Curcumin's widespread availability, safety, low cost and multiple cancer fighting functions justify its development as a drug for cancer treatment. A growing list of nanomedicine(s) using first line therapeutic drugs have been approved or are under consideration by the Food and Drug Administration (FDA) to improve human health. These nanotechnology strategies may help to overcome challenges and ease the translation of curcumin from bench to clinical application. Prominent research is reviewed which shows that advanced drug delivery of curcumin (curcumin nanoformulations or curcumin nanomedicine) is able to leverage therapeutic benefits by improving bioavailability and pharmacokinetics which in turn improves binding, internalization and targeting of tumor(s).

The above list provides a very constricted view on the various therapeutic benefits of secondary metabolites. These golden molecules when harnessed and developed in the right dosage form using green, sustainable, modern pharmaceutical procedures can revolutionize human healthcare. The vast repertoires of these metabolites are attributed to differences among species integrating into the treasure of biodiversity. The phenomenon of natural selection has produced highly efficient and aligned biological systems have enriched the value of all life forms by offering molecules with therapeutic, aesthetic and nutritional benefits.

The need of the day is to acknowledge the role of Mother Nature as our ultimate healer and up-lifter through the bounty of biodiversity. This can only be achieved when we humans decipher the gift of biodiversity in the most sustainable and eco-friendly way for the benefit of all species. Biodiversity thus paves a new road to enriching human life via its little precious molecules….if preserved with ultimate care, the advances in science and technology combined with the power of natures bounty will carve a niche for a better Earth in the years to come. Summing up, it is :

"FOOD FOR THOUGHT AND THOUGHTS FOR FOOD"

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