Insight Ethnopharmacology 2 (1): 3-4, 2012
ISSN 2078-2069 / DOI: 10.5567/ETHNOPHARMA-IK.2012.3.4

Nitric Oxide Inhibitory Activity of Bryophytes

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Bryophtes, evolutionary placed between the algae and pteridophytes are divided into three classes such as hepatics, hornworts and mosses. Bryophytes have about 24,000 species worldwide (Asakawa, 2007). Bryophytes house a number of biologically active compounds with potential pharmacological efficacy. They have shown to possess antioxidative (Dey and De, 2012), cytotoxic (Ohta *et al*., 1977), antifungal (Alam *et al*., 2011), antibacterial (Elibol *et al*., 2011), antifeedant (Perry *et al*., 2003) and vasorelaxant (Morita *et al*., 2011) activities. Bryophytes are also reported to be medicinally used by different ethnic communities (Harris, 2008). The present report chronologically compiles nitric oxide inhibitory activity of bryophytes.

Nitric oxide synthases (EC 1.14.13.39) are the enzymes which catalyze the production of nitric oxide (NO) (a cellular signaling molecule) from L-arginine. NO is also an important signaling molecule in plant system (Del Rio *et al*., 2004). Nitric Oxide Synthase (NOS) are made up of two NOS monomers with two calmodulins (CaMs). Three different isoforms of the enzyme occur in humans with 51-57% homology. They are nNOS (predominant in neuronal tissue, present in chromosome 12, 1434 amino acids, 161 kDa protein size), iNOS (inducible, present in chromosome 17, 1153 amino acids, 131 kDa protein size) and eNOS (occurs in vascular endothelial cells, present in chromosome, 1203 amino acids, 133 kDa protein size) (Alderton *et al*., 2001). A similar overall catalytic scheme is being followed by different NOSs (Michel and Feron, 1997). Apart from these three variants in humans, bNOS occurs in various Gram positive bacteria which help them to combat oxidative stress, antibiotics and host immune response.

Bis (bibenzyls) from liverworts were also found to inhibit Lipopolysaccharide (LPS)-induced NOS (iNOS) in RAW 264.7 macrophages and the inhibition was found to occur at the RNA level (Harinantenaina *et al*., 2005). Eight compounds (prenyl bibenzyls and clerodane diterpenoids) including 2-geranyl-3,5-dihydroxybibenzyl isolated from *Radula appressa* and *Thysananthus spathulistipus* have shown NO inhibitory activity (Harinantenaina *et al*., 2006). LPS-iNOS mRNA in RAW 264.7 cells was inhibited by herbertenoids and cuparenoids isolated from the liverworts (Harinantenaina *et al*., 2007). Myltaylane-type sesuiterpenoids, myltayl-4 (12)-ene-2-caffeate has shown potent NO inhibitory activity in LPS-induced RAW 264.7 cells (Harinantenaina and Asakawa, 2007). Compounds ent-kauren-15-one, norpinguisone and norpinguisone methyl ester isolated from the liverwort *Porella densifolia* from Vietnam have shown NO inhibitory activity in LPS-induced RAW 264.7 cells (Quang and Asakawa, 2010).

In the end, it can be said that, although, the group of bryophytes represent a very small percentage of plants present on earth and is mostly ignored economically due to their small size and insignificant appearance, the members of this group are certainly possess some phytoconstituents with pharmacological activity. They have shown a great deal of response in order to inhibit Lipopolysaccharide (LPS)-induced NOS (iNOS) in RAW 264.7 macrophages. Pharmacological efficacy of the group studied *in vitro* can be extended to the *in vivo* level, positive results from which may lead to the clinical trials and discovery of novel drugs.

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