

Betalains: Multifunctional Medicinal Bio-pigments

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Abstract

Betalains are vacuolar N-heterocyclic highly bioactive pigments found in plants of about 17 families in the order Caryophyllales. It has been reported that betalain preparations from different plant parts are safe for consumption and several in vitro and in vivo studies have disclosed a wide range of pharmacological activities including antioxidant, anti-inflammatory, anti-tumor, anti-diabetic and hepatoprotective properties for betalains. It seems that betalains can be potent safe medicinal bio-pigments due to having several pharmacological activities as well as biosafety. However, further studies are still needed to determine the long-term safety of betalains administration particularly in clinical trials and explore the precise mechanisms of action.

Keywords: Betalains; Betanin; Plant Pigment; Inflammation; Oxidative Stress

Introduction

Betalains are vacuolar N-heterocyclic highly bioactive pigments found in plants of about 17 families in the order Caryophyllales [1-3]. Betalain family members are categorized as red-violet-colored betacyanin pigments or yellow-orange-colored beta xanthin pigments [4]. It has been reported that betalain preparations from different plant parts are safe for consumption and several in vitro and in vivo studies have disclosed a wide range of pharmacological activities for betalains [5-7].

Antioxidant properties

It has been shown that betalains can exhibit significant cytoprotective effects against oxidative stress-induced cellular damages [6]. Accordingly, it has been revealed that betanin and betanidin, two betalain metabolites, can reduce cytochrome C oxidase-related linoleate damage and H₂O₂-activated metmyoglobin and free iron induced lipid membrane oxidation [8]. It has also been demonstrated that betacyanin attenuate D-galactose-induced neurotoxicity in mice through antioxidant defense

system restoration along with lipid peroxidation reduction [9]. Further, it was found that betanin provides protection against H₂O₂- and ONOO-induced DNA damages through free radicals scavenging and betalains inhibit oxidative stress via paraoxonase 1, an antioxidant enzyme produced in the liver, transactivation [10,11].

Anti-inflammatory activities

A growing body of evidence illustrates that betalains show anti-inflammatory functions through interfering with pro-inflammatory signaling cascades [5]. In a parallel manner, it has been indicated that betanin may have nephroprotective effects against paraquat-induced acute renal injuries in rats via inflammatory reactions inhibition [12]. Additionally, betalains have also been shown to noticeably suppress *in vitro* expression of cyclooxygenase-2, an important enzyme converting arachidonic acid to leukotrienes and prostaglandins, which are chemical mediators of inflammation [13]. Widening the scope it has been reported previously that betalain-rich extract reduces osteoarthritis-associated inflammation [14].

Anti-tumor effects

Reportedly, it has been clarified that betalains exhibit antiproliferative activities through angiogenesis inhibition as well as apoptosis induction [15]. Moreover, previous findings particularly in human cell lines including pancreatic, breast and prostate cancer cell lines have suggested betalains as promising agents for chemotherapy strategies promotion [16].

Hepatoprotective and anti-diabetic functions

It has been shown that betalains can exert hepatoprotection against N-nitrosodiethylamine and carbon tetrachloride as well as 7, 12-dimethylbenz (a) anthracene hepatotoxicities through phase II enzyme quinone reductase expression elevation and hepatic tissue oxidant/antioxidant balance improvement [16-18]. Furthermore, previous studies have proposed betalains as potent anti-diabetic compounds to counteract hyperglycemia-related complications [19,20].

Conclusion

Collectively, betalains appear to be potent safe medicinal bio-pigments due to having several pharmacological activities including antioxidant, anti-inflammatory, anti-tumor, anti-diabetic and hepatoprotective properties. However, further studies are

still needed to determine the long-term safety of betalains administration particularly in clinical trials.

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