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Nitric oxide alleviates heat stress-induced oxidative damage in *Pleurotus eryngii* var. *tuoliensis*

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ABSTRACT

High temperature is one of the major impediments limiting the growth and development of most edible fungi. While many efforts have been made in agricultural practice, the mechanism for resistance to high temperature remains elusive. Nitric oxide (NO) is considered as a signaling molecule involved in regulation of diverse physiological processes and stress responses in animals and plants. However, the role of NO in regulating fungal, particularly edible fungi, response to abiotic stresses, is unknown. The present study demonstrated that NO could effectively alleviate oxidative damage induced by heat stress in mycelia of *Pleurotus eryngii* var. *tuoliensis*. Heat stress induced increased thiobarbituric acid reactive substance (TBARS) content in mycelia, and the NO donor sodium nitroprusside (SNP) dramatically decreased TBARS content under high temperature. Moreover, the specific NO scavenger, 2-(4-carboxyphenyl)-4,4,5,5-tetramethylimidazoline-1-1-oxyl-3-oxide (cPTIO), could arrest the SNP action under the stress. Heat stress induced an increase in endogenous NO production in mycelial cells. However, the effect was significantly blocked by the NO synthase (NOS) inhibitor L-N^G-nitroarginine methyl ester (L-NAME). In contrast, nitrate reductase (NR) activities were not obviously altered during heat stress. The NR suppressor tungstate had no effect on intracellular NO abundance under heat stress. These results suggest that NO can effectively protect mycelia of edible fungi from heat stress-induced oxidative damage and the NOS-dependent NO production may participate in the response to heat stress.

1. Introduction

The edible oyster mushroom, *Pleurotus eryngii* var. *tuoliensis*, is one of the most widely cultivated mushrooms in China. It is praised as white *Ganoderma lucidum* because it is not only delicious and nutrient, but also has various pharmaceutical activities such as antitumor (Choi et al., 2006), antihypertensive (Miyazawa et al., 2008) and antiviral (Lv et al., 2009) properties. Higher temperature is one of the important environmental factors that influence mushroom growth and development. It is shown that the optimal temperature for most of *P. eryngii* var. *tuoliensis* mycelium growth is 25 °C, while that for fruiting induction and development usually stands within 13–18 °C (Kong, 2004). Besides, heat shock or sudden increase in environmental temperature is also a potential challenge to mushroom growth and development. Heat stress for several days would inhibit the mycelium growth, impair fruiting, and finally affect the quality of mushroom (Chang and Miles, 2004). Thus, it is necessary to investigate the mechanisms behind heat-resistant and stress responses of *P. eryngii* var. *tuoliensis*.

Nitric oxide (NO) is a small gaseous and water-soluble molecule, participating in signaling pathways in organisms (Durner et al., 1999). It regulates many aspects of physiological processes and responses to abiotic stresses in plants (Wilson et al., 2008). NO is a dual functional molecule. While low levels of NO eliminate the reactive oxygen species (ROS) such as superoxide anion O_2^- (Mittler, 2002; Vranova et al., 2002), high concentrations of NO enhance superoxide production in mitochondria by inhibiting electron flow cytochrome C oxidase (Millar and Day, 1996). In the former case, modulation of superoxide formation and inhibition of lipid peroxidation by both exogenous and endogenous NO illustrates its potent antioxidant role (Caro and Puntarulo, 1998; Boveris et al., 2000). The antioxidant role of NO is mainly based on its ability to maintain the cellular redox homeostasis and depress the generation of ROS directly (Wellburn, 1990; Shingles et al., 1996; Neill et al., 2002). Abiotic stresses such as high temperature can induce production of endogenous NO. Examples came from alfalfa (Leshem, 2001) and tobacco cells (Gould et al., 2003), where a rapid and significant surge in NO levels were activated by heat stress.

Compared to ample researches in plants, little information is known about the role of NO in fungi. NO at low concentrations protects *Saccharomyces cerevisiae* against heavy metal Cu^{2+} toxicity, while high concentrations of NO have opposite effects (Chiang

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