

## Physio-biochemical Responses of Okra (*Abelmoschus esculentus*) to Oxidative Stress Under Low Temperature Storage

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Okra pods, commonly eaten at an immature stage, undergo quick postharvest deterioration due to high respiration, water loss, wilting, toughening and decay. As okra is a tropical crop, its pods are susceptible to chilling injury (CI) at low storage temperatures. The effects of low temperature storage on the physio-biochemical properties of okra pods were determined. Chilling injury symptoms were found only in pods stored at 4°C and were more apparent after transfer to 25°C. In seeds, the CI index was positively correlated with seed browning, H<sub>2</sub>O<sub>2</sub>, malondialdehyde (MDA) content, and catalase (CAT) activity. Chilling-injured seeds had lower total phenolic content (TPC), antioxidant activity (DPPH scavenging activity and FRAP assay), peroxidase (POD), and superoxide dismutase (SOD) activities than non-injured seeds. Additionally, the seed browning index was related to high polyphenol oxidase (PPO) activity. In the pericarp, the CI index was also positively correlated with the H<sub>2</sub>O<sub>2</sub> and MDA contents. The POD and SOD activities in chilling-injured pericarp were significantly lower than in non-injured pericarp. Chilling injury resulted in an initial increase in DPPH scavenging and CAT activities which later decreased as CI became severe. These results indicate that CI in okra is due to accumulation of H<sub>2</sub>O<sub>2</sub>, and MDA, as well as its weak antioxidant defense mechanism. This resulted in development of CI symptoms, including seed browning.

**Key Words:** antioxidants, browning, chilling injury, hydrogen peroxide.

### Introduction

Okra (*Abelmoschus esculentus*) is a flowering plant of the mallow family, Malvaceae. Its pods are rich in minerals, vitamins, and antioxidant compounds (Liao et al., 2012; Lin et al., 2014; Sreeshma and Bindu, 2013). Fresh okra pods have long been used in traditional medicine to treat diabetes, gastric ulcer, jaundice, and hepatitis (Karim et al., 2014). Immature okra pods are usually consumed fresh or cooked. However, they have a short postharvest shelf life due to high respiration, especially when stored at an ambient temperature, and are susceptible to mechanical injury (bruising), desiccation, chlorophyll degradation and decay during postharvest handling (Babarinde and Fabunmi, 2009;

Finger et al., 2008). Low temperature storage has been proposed to maintain the postharvest quality of okra pods, but prolonged storage at low temperature results in chilling injury (CI).

Chilling injury is known as a serious postharvest problem that affects the marketability and storability of most harvested agricultural produce of subtropical and tropical origin. Visible symptoms of CI in okra pods include pitting, surface browning, water-soaked lesions and decay (Huang et al., 2012). Chilling is known to stimulate physiological changes such as loss of firmness, fresh weight and color, and a high respiration rate (Carvajal et al., 2011; Wang et al., 2007). Chilling-induced browning due to oxidation of phenolics by the activity of PPO has been reported in basil (Wongsheree et al., 2009) and eggplant (Gao et al., 2015).

Chilling stress induces the overproduction of reactive oxygen species (ROS) (Wismer, 2003), which structurally consist of one or more activated oxygen atoms such as superoxide radicals, hydrogen peroxide (H<sub>2</sub>O<sub>2</sub>), hy-

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