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Review

The role of the anaerobic metabolites, acetaldehyde and ethanol, in fruit ripening, enhancement of fruit quality and fruit deterioration

Edna Pesis *

Department of Postharvest Science of Fresh Produce, The Volcani Center, ARO, P.O. Box 6, Bet Dagan 50250, Israel

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Abstract

During fruit ripening on the tree and after harvest some essential processes involve the production of the anaerobic metabolites, acetaldehyde (AA) and ethanol. These processes include the production of aroma volatiles and removal of fruit astringency. Acetaldehyde, a natural aroma component, is present in almost every fruit; it accumulates during ripening even under aerobic conditions, but to a much greater extent under partially or totally anaerobic conditions. Partially anaerobic conditions often occur during fruit ripening and under storage conditions, for example, through coating with waxes or other films, or in modified and controlled atmospheres.

A requirement for anaerobic metabolites in normal ripening provided the initial indication that the application of such anaerobic metabolites might be beneficial for postharvest fruit quality. In some fruit it was found that application of ethanol or AA alone can affect fruit ripening on the tree, for example, in figs (to induce maturity), banana and persimmon (to remove astringency), and grape (to increase anthocyanins). In the postharvest period anaerobic metabolites may be applied to induce volatile production and to improve fruit aroma. In addition, it has been found that AA has fungicidal and insecticidal activity. Acetaldehyde and ethanol have been shown to be capable of retarding senescence and inhibiting ethylene production in plants, leading to less chilling injury symptoms in various fruit.

However, anaerobic metabolites should be applied carefully, depending on the species and variety of the fruit. Subtropical fruit are among the most sensitive to anaerobiosis damage, but application of AA in high concentrations can be phytotoxic to all fruit.

Keywords: Postharvest physiology; Low O_2; High CO_2; Ethylene; Chilling injury; Astringency removal; Aroma volatiles; Natural fungicide and insecticide

* Tel.: +972 3 9683612; fax: +972 3 9683622.
E-mail address: epesis@agri.gov.il.

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Contents

1. Introduction

The production of the two anaerobic metabolites acetaldehyde (AA) and ethanol in fruit, while still on the tree or in the postharvest period, leads to dramatic changes in fruit ripening. Acetaldehyde is a very reactive compound that can form covalent bonds with residues of NH_2 or SH (Lieber, 1988). In various proteins, it has been shown that AA can form covalent bonds with NH_2 residues of lysine via a Schiff base (Tuma et al., 1987; Lieber, 1988; Perata et al., 1992). Formation of AA-protein adducts has been shown in carrot cells treated with ethanol (Perata et al., 1992).

During fruit ripening on the tree some processes, such as production of aroma volatiles and removal of astringency, involve the production of anaerobic metabolites, and the requirement for anaerobic metabolites in normal ripening on the tree was the initial indication that the application of anaerobic metabolites might be beneficial for postharvest fruit quality. In addition, fruit often experience anaerobic conditions during postharvest storage, e.g. under controlled (CA) or modified atmosphere (MA) storage, or after coating with various waxes. The application of AA and ethanol has also been used for many years for sterilization and for their fungicidal and insecticidal properties.

This review will concentrate mainly on the roles of endogenously produced or exogenously applied AA and ethanol in fruit ripening and their effect on fruit quality.