Ethylene flux in postharvest kiwifruit systems

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Abstract

Damaged or rotten kiwifruit or change of environmental conditions (temperature) through the supply chain may trigger premature ripening and softening of sound fruit as a result of the expected higher rates of ethylene production caused by these events. This thesis quantified some of the key factors which will govern ethylene composition within a commercial kiwifruit package (targeting 'Hayward' variety) as a preliminary step for constructing a predictive model that enable interpreting of ethylene from the sensor which could be used in detecting quality of kiwifruit within a package.

Ethylene production was found to be strongly associated with kiwifruit firmness and temperature of 'Hayward' kiwifruit. Maximal ethylene production (16,000 to 120,000 times that of minimal production) was observed when kiwifruit firmness reached less than 13 N suggesting that detection of ethylene concentration within a kiwifruit box should be able to be used to provide a reasonable estimate of the firmness of the fruit within the package. Lower rates of ethylene production were measured at 0 and 2 °C in comparison to previously reported data due to the advantage of using a newly developed high sensitivity ethylene detector, ETD-300 in present study. Ethylene production data obtained at a broad range of potential supply chain temperatures (0, 2, 5, 10 and 20 °C) concluded that at higher temperature (10 and 20 °C) initiation of an observable increase in ethylene production occurs at an earlier stage of firmness (10.5-13 N) while firmness of kiwifruit should reduce more (5.6-5.7 N) to observe this at lower temperature (0 and 2 °C). A simple mathematical model was developed which can be used to predict the ethylene production of 'Hayward' kiwifruit given a known fruit quality (firmness) and temperature condition.

Impact injured 'Hayward' kiwifruit produced high ethylene as a typical 'stress/wound' physiological response and results strongly indicated that temperature plays a significant role in controlling synthesis of wound ethylene by showing no effect at 0 °C and 2-3 times increase of ethylene production at 20 °C than at 5 °C. Two fold increase of rate of ethylene production was observed with different degree of impact damage (30, 60 and 120 cm drop heights) adding evidence to the effect of severity/degree of injury on increase of wound induced ethylene. Moreover, results

of two different maturity levels of kiwifruit demonstrated the further effect of firmness reduction of kiwifruit on increase of impact injury ethylene production.

A one to twenty times increase in ethylene evolution rate for 'Hayward' kiwifruit following subsequent transfer to a higher temperature from a lower temperature (0→2 °C, 2→5 °C, 5→10 °C, 10→20 °C) was demonstrated. Mathematical estimation of the desorbed ethylene at each transient increase of temperature using Henry's law revealed that there are other factors (via ethylene synthesis pathway) contribute to the escalation of ethylene evolution observed during and immediately subsequent to an increase in temperature other than contribution from the release of dissolved ethylene in the kiwifruit tissue based on Henry's law.

A six to eight times greater permeability of current commercial kiwifruit polyliner (HDPE) than what reported in literature for the similar type of film demonstrated the ethylene permeability differences that can be found as a result of the structure of the film (physical and chemical) as well as experimental conditions that are often not reported alongside the data presented. Permeability of the polyliner was found to be dependent on temperature as well as with concentration of ethylene. The model established to predict ethylene composition within different types of commercial packages available in the industry using log ethylene production rate ($fmol.kg^{-1}s^{-1}$) of kiwifruit and permeability of the polyliner ($mol.m.m^{-2}s^{-1}Pa^{-1}$) shows a 1.5 fold increase of log ethylene concentration (mPa) inside the kiwifruit package with the temperature decrease from 20 ºC to 0 ºC irrespective to the type of package.

Out of all the factors considered, the approximately 10,000–100,000 fold increase of ethylene production due to firmness change of kiwifruit dwarfs the 2-20 fold increase (due to injury or temporary temperature change) indicating that the ability to detect ethylene concentration inside a kiwifruit package could be applied in getting the information of the quality of the fruit (firmness) inside the package and hence identify the kiwifruit which require remedial action within the product stock.

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