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Effect of various citrus sizes on the resistance to gas diffusion

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Abstract

This study investigated the effect of various sizes of citrus on their resistance (*R*) to gas diffusion. The purpose of the investigation was to compare the value of *R* in 3 different sizes of citrus. To measure the *R* to gas diffusion in citrus, the study applied ethane efflux method. This is the method which the evolution phenomenon of ethane was measured by applying Fick's Law. The results showed that *R* of ethane (C_2H_6) gas was dependent on citrus size. It can be seen that the larger the size of the fruit, the greater the *R* value, i.e. M size had R=4.33x10^5s.m^{-1}, L size had R=4.99 x10^5s.m^{-1} and 3L size had R=6.84 x10^5s.m^{-1}.This finding indicated that the fruit sizes can be considered as an important factor in designing storage control atmosphere (CA) condition for citrus.

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Keywords: Citrus Size; resistance; gas diffusion

1. Introduction

Citrus is the most widely produced fruit. It has many varieties and it grows in more than 80 countries[1]. Considering the therapeutic value of these fruits and human health awareness, citrus gets world's interest. Hence, the consumption degree of this fruit tends to increase. Citrus fruit production concerns for the sustainability challenges in the past, including pesticide use, post-harvest quality, and change of consumer preferences[2]. In this study, we focus on the post-harvest aspect.

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Nomenclature

ds/dt	amount of gas movement ($10^{-6}m^3.s^{-1}$)
A	surface area of fruit (m^2)
C_{in}, C_{out}	gas concentration in and outside product ($10^{-6}m^3.m^{-3}$)
t	time (s)
R	resistance ($s.m^{-1}$)
V_{in}	intercellular space volume (m^3)
k	negative slope of a plot of In (1- C_{out}^t/C^{∞}) versus t (s^{-1})
C^{∞}	concentration of ethanein the close box after equilibrium ($10^{-6}m^3.m^{-3}$)
V_t	total volume of fruit (m^3)
m	fruit mass (g)
$Ø$	porosity (%)
V_1, V_2	rate of gases diffusion ($m.s^{-1}$)
M_1, M_2	molecular weights of gases ($g.mol^{-1}$)
R_1, R_2	resistance of gases ($s.m^{-1}$)
P_a	apparent density of fruit ($g.m^{-3}$)

One beneficial effect of controlled atmosphere (CA) storage is to extend the postharvest life of fruit and vegetables. The precise temperature and level of O_2 and CO_2 are required to maximize storage life and to minimize storage defects. The empirical study on many fruits showed that oxygen can be lowered in CA storage ranging from 1% to 5% without subsequent defects [3].

The concentration limits for O_2 reduction and CO_2 enrichment in CA storage depends on the number of factors which include the respiration rate and the "tolerance" of the tissue toward lowered O_2 or increased CO_2. Meanwhile, one physical factor governing "tolerance" often left behind is the resistance (*R*) to gas diffusion[4].

The knowledge of *R* in gas transport properties is essential for calculating the internal concentration of O_2 and CO_2 in the fruit when the information of storage gas concentrations are available[5]. Therefore, the understanding of resistance (*R*) in the CA storage is needed to predict permissible minimum gas levels in CA storage. It will also provide invaluable information of the physiological defect that may develop during CA storage time. In Japan, one citrus species sometimes has different sizes when ready to be consumed. Then it is necessary to preserve their long life based on their sizes with such postharvest technology, like CA storage. From the above explanation, it can be concluded that *R* in different sizes is an important factor to be investigated. However, information about the effect of fruit size on *R* is unavailable. Thus, the current research was initiated to study the effect of citrus size in three different sizes of citrus on *R* to gas diffusion.

2. Material and methods

2.1. Materials

Iyokan (*Citrus iyo Hort. ex Tanaka*) species in three different sizes (M, L, 3L) were used in this research. They were harvested on 27 January 2014 and stored in refrigerator for 9 week at 5^0 C during *R* measurement.

2.2. Methods of measuring resistance of ethane (C_2H_6)

The resistance to gas diffusion in citrus was determined by ethane efflux method[7]. Based on this method, single fruit was firstly placed in a jar purged with constant flow of air containing 1,800-2,000 ppm ethane. The duration required to reach the equilibrium was 5 hour (Fig. 1, step A). Next, the single fruit was transferred quickly in to another box (Fig. 1, step B). At the time of sealing, an AC fan attached to the box was turned on to ensure rapid mixing. Evolved ethane concentration from the fruit was measured by gas chromatograph at constant time interval. For picking the precise ethane, 0.5 ml gas samples were withdrawn at regular intervals through a septum attached to