Effect of surface coating using wax extracted from cabbage leaf on water vapor permeance of fresh lime

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Abstract

This study extracted wax from cabbage leaf through the Soxhlet extraction method using ethanol liquid as an organic solvent at 90ºC for 8 hours. The extracted wax was later dissolved with ethanol solvent to prepare surface coating material which was subsequently used to coat on the surface of fresh limes to study effective water vapor permeance (WVP). The results were compared with limes coated with chitosan solution and non-coated limes, as the control. Results showed that the average WVP value (1.4 µmol/s/m^2/Pa) of limes coated with the extract was comparable with that of limes coated with chitosan (1.5 µmol/s/m^2/Pa). Both values were lower than the WVP of the control (3 µmol/s/m^2/Pa). The surface coating increased resistance to water vapor loss from the limes which is a major cause of weight loss. The fresh appearance of limes coated with the extracted wax was similar to those coated with chitosan. However, wrinkles were observed on the surface of non-coated limes. Experimental results highlight that wax extracted from the cabbage leaves can decrease water vapor permeance and quality changes of limes.

Keywords: water vapor permeance**,** coating, cabbage leaf wax extracted**,** water loss, lime

Introduction

Weight loss of fresh limes causes a reduction in marketing value. The key factor attributed to this is the impairment or loss of natural wax on the lime surface. This wax functionally protects water vapor loss from the fruit which is a major contribution to weight loss. Losses of wax subsequently lead to weight loss, through facilitating water vapor losses from the fruit [1]. Water losses also cause a wrinkled appearance of the lime surface as an undesirable effect noted by consumers [2]. In practice, surface coating of limes has been industrially implemented with shellac and carnauba wax. These materials, in particular shellac, have to be imported and increase the cost of the fruit [3].

The literature contains no reports of surface coating using wax extracted from cabbage leaf for limes or other horticultural products. As previously mentioned, surface coating increases the barrier to water vapor loss. The loss rate is dependent on a range of factors including the surface area to volume ratio of the fruit, temperature, and relative humidity [2]. This study focused on effective water vapor permeance (WVP) which is an important physicochemical property governing steady-state transfer rate. The effects of surface coating using wax extracted from cabbage leaves to decrease the WVP of fresh limes were investigated.

Materials and methods

Raw material

Cabbage leaves and limes (variety Pann) were purchased from Warin Charoensri Market, Warin Chamrap, Ubon Ratchathani, Thailand.

Wax extraction from cabbage leaves

The cabbage leaves chosen for wax extraction were outer leaves with fractures, cracks, penetration of insects, and leaf scars. The extraction wax methodology followed the Soxhlet approach reported by Zhao and Zhang [4] with some modifications. The leaves were cut into pieces and dried using a hot air oven at 103°C for 5 hours (17% w/w (dry basis) moisture content for dried cabbage leaves). Dried samples were placed in a desiccator at room

temperature (35°C±2). For extraction, 5 g of the samples were added to 150 ml of ethanol liquid (99% w/v) and extracted using Soxhlet equipment (Soxtherm, Metrology Technologies Co., Ltd., US) for 8 hours at 90°C. The extracted wax was left in the fume hood for the ethanol to evaporate. The wax was further dried using a hot air oven at 105°C for 24 hours and kept in a desiccator (16% w/w (dry basis) moisture content of the wax).

Lime surface coating

To make the surface coating material, the dried wax was mixed with ethanol liquid at a 0.5: 5 (w/v) ratio. Individual lime fruit was coated using a brush dipped in the coating material. The lime surface was brushed thoroughly and thereafter was left to dry in the place where the fan was operated. Similar coating practice was applied to the chitosan coating. The effective WVP of wax extracted from the cabbage leaves was compared to that of chitosan material coating and non-coated limes (the latter was designated as control). All treatments were maintained and tested at 25°C.

It should be noted that the fresh limes were left in the 25ºC controlled room for 18 hours to become equilibrium with the storage temperature prior being coated with either chitosan or wax extracted from cabbage leaves. The preliminary tests showed that the fruit temperature (T_{fr}), measured using the thermocouple probe, was averagely equal to the storage room temperature in which the fruit was stored.

Calculation of effective WVP

The effective WVP values for coated and non-coated limes were calculated using Eqs. 1-3 following Utto [5]. The lime surface area was measuring using a leaf area measuring meter (Area meter Li-3100, Nebraska, USA). To measure the surface area, individual limes were wrapped with opaque tape which was later cut and peeled off from the lime using a sharp knife. The tape was spread out and flattened on a transparent sheet inserted into the leaf area measuring meter. The surface area was estimated from the opaque section laid on the sheet.

$$P_{fr}^{H_2O} = \frac{r_{fr}^{H_2O}}{\left(p_{fr}^{H_2O} - p_{env}^{H_2O}\right) \times A_{fr}} \quad (1)$$

where,

$p_{fr}^{H_2O}$ = partial pressure of water vapor inside fruit (Pa),

$r_{fr}^{H_2O}$ = rate of water loss from fruit (mol/s)

$p_{env}^{H_2O}$ = partial pressure of water vapor in the atmosphere surrounding fruit (Pa)

A_{fr} = fruit surface area (m^2).

Values of $p_{fr}^{H_2O}$ and $p_{env}^{H_2O}$ were calculated using Eqs. 2 and 3.

$$p_{fr}^{H_2O} = 611 \cdot \exp\left(17.27 \cdot \left(\frac{T_{fr}}{T_{fr} + 237.3}\right)\right) \times a_w \quad (2)$$

where,

T_{fr} = fruit temperature (°C) (i.e. 25 ºC)

a_w = water activity (defined as 0.995 in accordance to Maguire [6]).

$$p_{env}^{H_2O} = 611 \cdot \exp\left(17.27\left(\frac{T_{wb}}{T_{wb} + 237.3}\right)\right) - \gamma\left(T_{db} - T_{wb}\right) \quad (3)$$

where,

T_{wb} = wet bulb temperature (°C),

T_{db} = dry bulb temperature (°C), and

γ = constant (defined as 67 $Pa \cdot C^{-1}$).

Results and discussion

The average value of effective WVP for fresh limes coated with wax extracted from cabbage leaves was 1.4 µmol/s/m^2/Pa. This was comparable to limes coated with chitosan coating material (100%), of 1.5 µmol/s/m^2/Pa. The effective WVP values of limes tested for both treatments were lower than for non-coated limes of 3 µmol/s/m^2/Pa (Figure 1). The reductions observed in effective WVP of the coated limes were attributed to the surface coating materials which decreased the rate of water vapor transfer from the lime to the immediate environment, due to the differences between the partial pressure of water vapor inside and outside the fruit [7]. The results highlighted that wax extracted from cabbage leaf reduced the loss of water vapor and, subsequently, fresh fruit weight. The capability of the cabbage leaf wax was

comparable to chitosan, showing potential as a suitable cheaper alternative for weight loss control.

Regarding lime appearance, limes coated with both coating materials had a greener color with only slight wrinkle marks on the surfaces (data not shown). In contrast, non-coated limes were yellowish green in color with a noticeably wrinkled appearance attributed to water vapor loss during storage [2]. The results for surface appearance support the application of wax extracted from cabbage leaves as a suitable surface coating material.

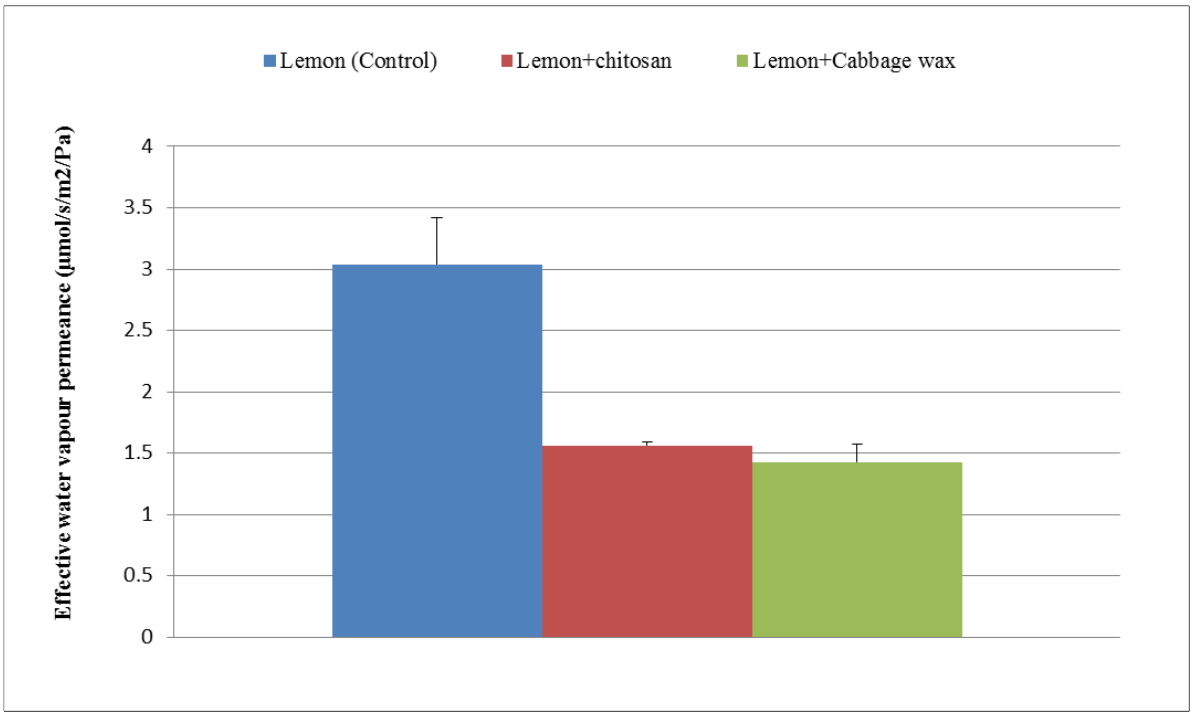

Figure 1. Effective WVP values of limes coated with surface coating materials (i) wax extracted from cabbage leaves (lemon + cabbage wax), (ii) chitosan (lemon + chitosan), and (iii) non-coated limes (Control) at 25°C (Data presented are averages with a standard deviation bar (n=3))

Conclusions

Experimental results showed that surface coating with wax extracted from cabbage leaf had a significant effect on reducing the WVP of the limes. The cabbage wax coating reduced water

loss from the fruit by forming an additional barrier on the lime surface. The coating also delayed changes in color and peel appearance of the limes.

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