THERMAL/PHYSICAL PROPERTIES AFFECT PREDICTED WEIGHT LOSS OF FRESH PEACHES

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ABSTRACT. *Many product thermal/physical properties used as model inputs are highly variable and some have not been independently determined. The chosen values of these properties can affect the accuracy of weight loss predictions. Peaches were selected as the product to study and three parameters, skin mass transfer coefficient (k_s), vapor-pressure lowering effect of dissolved solutes (VPL), and radius were identified as having considerable influence on predicted weight loss at 5 to 25°C, 50 to 100% RH, and 0.005 to 5.0 m/s air velocity conditions. The effects of k_s on predicted weight loss decreased with higher relative humidity and air velocity and lower temperature. VPL affected predicted weight loss most at higher temperature, and lower velocity and relative humidity. Varying input values of k_s and VPL resulted in predicted weight loss ranges that encompassed 71% of experimental weight loss values for peaches and those values not falling within the predicted values were mostly (88%) underpredicted.*

Keywords. *Moisture loss, Fresh produce, Peach, Thermal properties, Physical properties, Transpiration.*

Quality of fresh produce involves many attributes: appearance, texture, taste, and saleable weight. A major factor affecting these quality attributes is the exchange of water, specifically moisture loss or transpiration, between the product and the environment. For most fruits and vegetables, the maximum weight loss before the product is considered unsaleable is between 5 and 10% (Kays, 1991). In post harvest storage, the amount of moisture lost from a product can be controlled by the storage environment. Humidity, temperature, and air movement are three of the main environmental factors which can be controlled during storage to limit moisture loss.

Moisture loss during storage for high-moisture, respiring products can be investigated with the use of mathematical models. Due to the complexity of the governing equations, interactions of significant factors (i.e., temperature, respiration, and convective and radiation heat transfer), numerical methods have become more extensively used in recent years to predict moisture loss.

The mathematical model developed by Gaffney et al. (1985) used finite difference techniques to simultaneously solve the heat and mass transfer equations and considered six major components: air film resistance, vapor-pressure lowering effect, evaporative cooling, respiratory heat generation, convective heat transfer, radiative heat transfer, and carbon loss due to respiration, to predict weight loss. They found that considerable errors, as high as 100%, in weight loss calculations can occur if any of the components were omitted from the model. Chau et al. (1988) developed a model to describe transpiration from spherical, cylindrical, and slab-like products. From their equations, a transpiration value could be calculated with a known skin mass transfer coefficient and visa versa. Also, they concluded that transpiration (or skin mass transfer determination) was affected by respiration, evaporative cooling, and convective and radiative heat transfer, while radiation and respiration effects were lessened with high airflow. Sastry and Buffington (1982) developed a mathematical model which applied to spherical products at steady-state conditions having largely impervious uniform skin. Their model assumed that moisture loss occurred mostly through the pores, considering pore size and number as major factors. Majeed et al. (1980) predicted air cooling characteristics of food products in terms of Biot number, wet-bulb temperature, product initial temperature, and Fourier number; using finite difference techniques to solve coupled heat and mass transfer equations. Hayakawa and Succar (1982) considered time and temperature-dependent respiration and temperature-dependent thermal/physical properties (density and thermal conductivity) and used linear product temperature functions to approximate variations in respiration and physical properties. Chau and Gaffney (1990) modeled heat and mass transfer in spherical produce while accounting for conduction within the product, convection, internal heat generation, radiation, and evaporative cooling. The advantage of their model was the non-capacitance surface node (no associated volume) which allowed for much larger time steps with fewer nodes to provide accuracy comparable to other models.

The major factors to consider when modeling transpiration include: convection and radiation heat transfer; evaporation; respiration; vapor pressure lowering

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effect due to solutes in water of product; air velocity; variable thermal properties; and product shape, surface structure, and maturity (Hayakawa and Succar, 1982; Sastry and Buffington, 1982). Model developers have attempted to consider most or all these factors in their models, although including more factors produces a more complex model. One problem not addressed is the inaccuracy of input variables or parameters used in the modeling equations to predict moisture loss. These parameters are the physical and thermal properties which are assumed as "known" variables in the modeling equations.

Thermal/physical properties of the storage environment, i.e., air, have been extensively investigated. Relatively accurate values for these properties over a wide range of temperatures are readily available in the literature (Mohsenin, 1980; Toledo, 1994; ASHRAE, 1993; Geankoplis, 1993; Rao and Rizvi, 1995). On the other hand, thermal/physical properties of fresh fruits and vegetables are not as well defined due to the variability among commodities, differences among cultivars, and even differences among fruits of a cultivar, especially over the temperature ranges usually encountered in cooling and storage. Thermal/physical properties of peaches reported in literature included: density, radius, skin mass transfer coefficient, specific heat, thermal conductivity, and vapor pressure lowering effect. Peach density ranged from 950 to 990 kg/m^3 (Gaffney et al., 1985; Westwood, 1962). Radius ranged from 2.5 to 3.95 cm (Rigney et al., 1996; Delwiche and Baumgardner, 1986; Gaffney et al., 1985; Robertson et al., 1990; Westwood, 1962) and was dependent on grade. Specific heat and thermal conductivity had reported ranges of 3300 to 4100 J/kg·°C (Gaffney et al., 1985; Hardenburg et al., 1990; Mohsenin, 1990; Polly et al., 1980) and 0.51 to 0.587 W/m·°C (Gaffney et al., 1985; Mohsenin, 1990), respectively. Vapor pressure lowering effect either directly reported or calculated from freezing point depression (Gaffney et al., 1985) ranged from 0.98 to 0.995 (Chau et al., 1988; Hardenburg et al., 1990; Mitchell et al., 1974; Mohsenin, 1980; Polley et al., 1980). The skin mass transfer coefficient has been estimated by measuring other model parameters and then using models to back-calculate for a corresponding value of skin mass transfer coefficient, i.e., not measured directly. The values reported for this property ranged from 5 to 25 × 10^{-6} g/m^2·s·Pa and indications suggest that it be greater (Chau et al., 1988; Gaffney et al., 1985).

It has become more common to store produce at higher relative humidity and in modified atmospheres to gain even small reductions in weight loss or increases in storage time; requiring more accurate models to determine these small gains. Difficulties in accurately modeling weight loss at high relative humidity may be partly due to or compounded by inaccurate choice of input parameters. As values for these thermal/physical properties vary throughout the literature, efforts to model and maintain produce at extreme conditions would be enhanced by better understanding of these properties' effect on predicted weight loss. Thus, the objectives of this research were to identify those thermal/physical parameters of peaches which significantly affect transpiration and determine the degree of the effect of those significant parameters on weight loss at various storage conditions.

Methods and Procedures

A mathematical model (Whitelock, 1997) was used to analyze the effects product thermal/physical parameters had on weight loss prediction at many different storage conditions. The model assumed a homogeneous spherical product and included heat transfer in the radial direction, internal heat generation, and convective and radiation heat transfer and evaporative cooling boundary conditions. Temperature dependent respiration and air and water vapor properties were also incorporated. Coupled heat and mass transfer equations were solved using finite difference techniques.

Properties Influencing Weight Loss

Input parameters which influence prediction of weight loss include air thermal/physical properties and product thermal/physical properties. The effects of product properties were examined under the assumption that other model inputs were relatively accurate. As thermal/physical properties vary widely among different kinds of fresh produce, peaches were selected as the produce to study. Six peach thermal/physical properties were explored: density, radius, skin mass transfer coefficient, specific heat, thermal conductivity, and vapor-pressure lowering effect of dissolved solutes. Practical ranges for these variables were taken from the literature (table 1). Steady-state weight loss calculations were performed using all combinations of the maximum and minimum values for the thermal/physical variables for eight storage conditions; each combination of 5 and 25°C temperature, 50 and 99% RH, and 0.002 and 5 m/s air velocity. The results were analyzed to determine which parameters had a significant influence on the predicted weight loss.

Table 1. Ranges for thermal/physical parameters for peaches

Variable	Units	Range
Density	(kg/m^3)	950-990*,†
Radius	(m)	0.025-0.04‡,§,‖
Skin mass transfer coefficient	(g/m^2·s·Pa)	5-25 × 10^{-6}*,#,**
Specific heat	(J/kg·K)	3300-4100*,**,††,‡‡
Thermal conductivity	(W/m·K)	0.51-0.587*,**,††
Vapor pressure lowering effect		0.98-0.995#,††,‡‡,§§,‖

* Gaffney et al., 1985.
† Westwood, 1962.
‡ Delwiche and Baumgardner, 1986.
§ Robertson et al., 1990.
‖ Rigney et al., 1996.
Chau et al., 1988.
** Hayakawa and Succar, 1982.
†† Mohsenin, 1980.
‡‡ Polley et al., 1980.
§§ Hardenburg et al., 1990.
‖‖ Mitchell et al., 1974.

Sensitivity Analysis

Parameters which showed a particularly significant impact on model weight loss prediction were further examined to determine their degree of influence, individually and in combination with other parameters, at different storage conditions.

The constants, storage conditions, and variables examined in the analysis are shown in table 2. The constants were those peach properties which did not

Table 2. Constants and variables used in sensitivity analysis

Constant/Variable	Units	Value
Air velocity	(m/s)	0.005, 1, 5
Air temperature	(°C)	5, 25
Density	(kg/m^3)	970
Emissivity		0.90
Radius	(m)	0.035
Relative humidity	(%)	50, 90, 95-100
Skin mass transfer coefficient	(g/s·Pa·m^2)	5, 10, 15, 20, 25 × 10^{-6}
Specific heat	(J/kg·K)	3820
Thermal conductivity	(w/m·K)	0.581
Vapor pressure lowering effect		0.98, 0.985, 0.99, 0.995

significantly affect predicted weight loss over their minimum to maximum ranges and were thus held constant at their average values taken from the literature. The variables examined were those which did have significant influence on predicted weight loss over their minimum to maximum range.

Model runs were performed at each level of each storage condition and parameter examined. Results were analyzed to determine the influence of the parameters and their interactions at different storage conditions.

COMPARISON OF EXPERIMENTAL DATA WITH PREDICTED WEIGHT LOSS

Weight loss predicted by the model was compared with experimental weight loss measurements made by Whitelock et al. (1994). Thermal/physical properties used to simulate those of the experimental data are shown in table 3. The model was run at each level of skin mass transfer coefficient and vapor-pressure lowering effect to determine if experimental weight loss would fall within the range of predicted weight loss at the parameter extremes. The temperature, relative humidity, and air velocity varied from one storage condition to another in the experimental procedures. Hence, combinations of ambient conditions were used as model inputs to simulate storage conditions (table 4). At each storage temperature, 0.0005 m/s air velocity was used for negligible airflow. For experimental storage conditions where air velocity was not negligible, two air velocities, representing the range measured in the experiment, were used with the temperature and relative humidity for that condition. The weight loss predicted by the model for each set of ambient conditions was then compared with the experimental data.

Table 3. Model input thermal/physical properties of peaches for comparison of experimental data with model output

Properties	Units	Value
Density	(kg/m^3)	970
Radius	(m)	0.032
Skin mass transfer coefficient	(g/m^2·s·Pa)	5, 25 × 10^{-6}
Specific heat	(J/kg·°K)	3820
Thermal conductivity	(W/m·°K)	0.581
Vapor-pressure lowering effect		0.98, 0.995

Table 4. Model input ambient conditions to simulate experimental storage conditions

Temperature (°C)	Relative Humidity (%)	Air Velocity* (m/s)
6.3	96	Negligible
6.3	96	0.5-1.5
5.7	88	Negligible
5.7	88	0.7-4.0
4.1	68	Negligible
4.1	68	0.2-1.5

* 0.0005 m/s air velocity was used for negligible airflow.

RESULTS AND DISCUSSION

SIGNIFICANT PROPERTY IDENTIFICATION

Analysis of variance results showed that k_s, VPL, and R significantly influenced predicted weight loss over the range of storage conditions modeled (table 5). Skin mass transfer coefficient, k_s, was significant at all eight storage conditions. Vapor-pressure lowering effect of solutes, VPL, was significant at 99% RH, but not at 50% RH. Despite the fact that VPL did not have a significant influence on predicted weight loss at 50% RH, it was still considered in further analyses for its influence at high relative humidity. Although radius, R, was significant at all storage conditions, it was not considered for further analysis because of its relative ease of modeling, accuracy of measurement, and low variability when produce is size graded. It was concluded from this analysis that k_s and VPL were the main parameters that influenced weight loss prediction and warranted further study.

SENSITIVITY ANALYSIS

Steady-state weight loss was predicted at 48 storage conditions (air temperature, relative humidity, and velocity) for 20 k_s/VPL combinations. Predicted weight loss varied with changes in k_s and VPL and the storage conditions modeled affected the response of predicted weight loss to k_s and VPL.

Figures 1 to 5 show response of predicted weight loss to changes in k_s and VPL for 5 of 48 storage conditions modeled. Response of predicted weight loss to changes in k_s was nonlinear at 0.005 m/s air velocity and nearly linear at 5 m/s. This was due to the greater resistance of the boundary layer to moisture loss at low air velocity. At low air velocity, as k_s (skin permeability) increases weight loss also increases, but levels off at the higher values of k_s as the resistance to moisture loss by the boundary layer or microenvironment around the peach becomes the limiting factor. At high air velocity, the microenvironments around the peach are disturbed by the airflow, greatly reducing their resistance to moisture loss, thus moisture loss continues to increase with k_s. Predicted weight loss was a linear function of VPL for all storage conditions modeled.

Table 5. Probabilities* from ANOVA of effect of peach thermal/physical parameters on weight loss modeled at selected storage conditions

Storage Conditions			Parameters					
Temp. (°C)	RH (%)	Velocity (m/s)	Specific Heat	Thermal Cond.	Density	Skin Mass Trans. Coef.	Radius	Vapor Pressure Lowering Effect
5	50	0.002	1.00	1.00	0.36	0.01	0.01	0.63
		5	1.00	1.00	0.44	0.01	0.01	0.68
	99	0.002	0.98	1.00	0.81	0.01	0.01	0.01
		5	1.00	1.00	0.85	0.01	0.01	0.01
25	50	0.002	1.00	0.99	0.29	0.01	0.01	0.59
		5	1.00	0.99	0.44	0.01	0.01	0.68
	99	0.002	0.84	0.63	0.34	0.01	0.01	0.01
		5	1.00	0.95	0.84	0.01	0.01	0.01

* All 0.01 values are 0.007 or less.

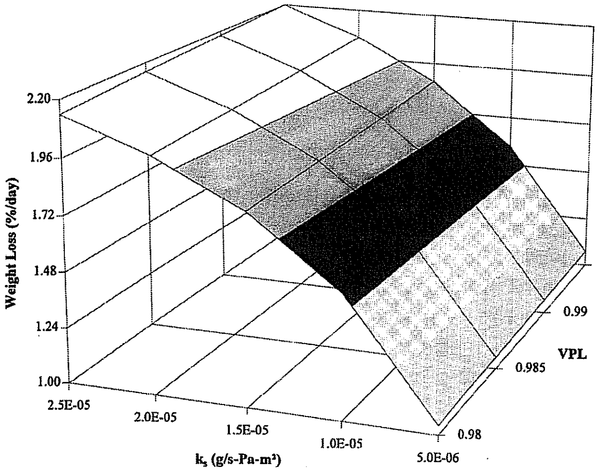

Figure 1—Response of weight loss to k_s and VPL for 5°C, 50% RH, and 0.005 m/s air velocity. Each shaded area represents approximately 20% of total change in weight loss.

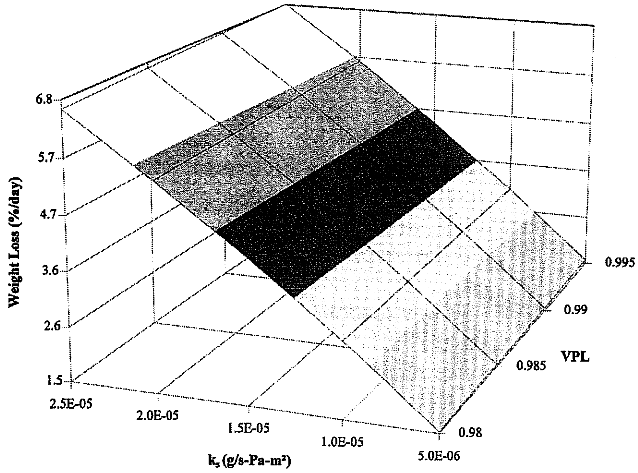

Figure 2—Response of weight loss to k_s and VPL for 5°C, 50% RH, and 5 m/s air velocity. Each shaded area represents approximately 20% of total change in weight loss.

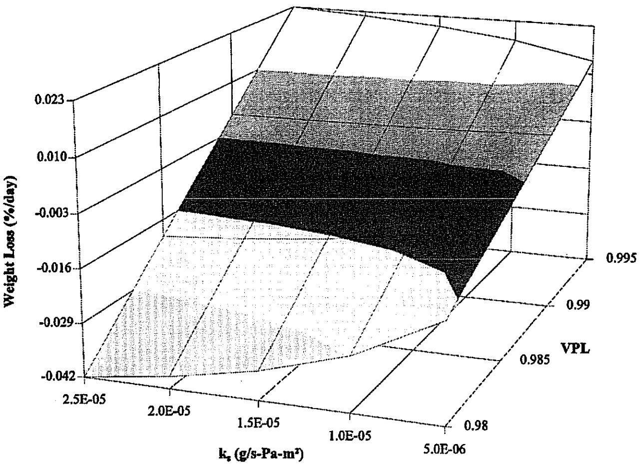

Figure 3—Response of weight loss to k_s and VPL for 5°C, 100% RH, and 0.005 m/s air velocity. Each shaded area represents approximately 20% of total change in weight loss.

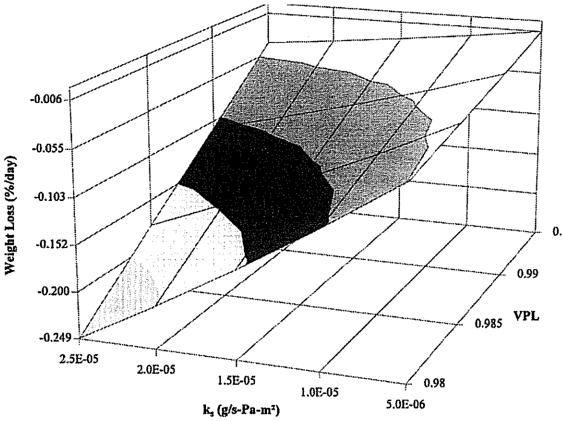

Figure 4—Response of weight loss to k_s and VPL for 5°C, 100% RH, and 5 m/s air velocity. Each shaded area represents approximately 20% of total change in weight loss.

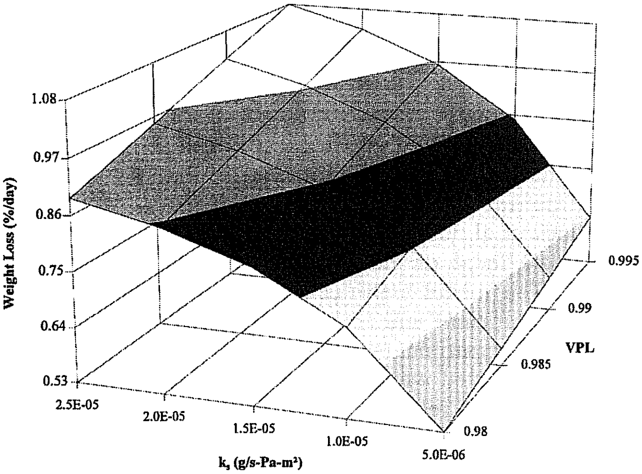

Figure 5—Response of weight loss to k_s and VPL for 25°C, 100% RH, and 0.005 m/s air velocity. Each shaded area represents approximately 20% of total change in weight loss.

Shaded areas, representing 20% change in weight loss, indicated that for low relative humidity the response of weight loss was largely due to k_s. At high relative humidity, the response was more dependent on VPL.

Predicted weight loss responded differently to k_s and VPL at different storage conditions. More importantly, choice of k_s and VPL affects the magnitude of the response of predicted weight loss at different storage conditions. Changes in k_s and VPL over their typical ranges caused large variations in weight loss at certain conditions.

PREDICTED WEIGHT LOSS AT THE LOWEST VALUES OF k_S AND VPL

WL_0, the predicted weight loss at the lowest k_s and VPL values, represented a starting point or datum line from which the effects of changes in the parameters studied could be measured. WL_0 at 5°C ranged from −0.05 to 1.53% per day (table 6). WL_0 decreased as relative humidity increased, becoming negative at or near 100% RH. The changes in WL_0 as relative humidity increased were enhanced by increasing air velocity. WL_0 at low relative humidity was greater and was more negative at

Table 6. Predicted weight loss for lowest values of k_s and VPL and F statistics for effect of k_s and VPL on predicted weight loss at different air velocities and relative humidities at 5°C

Vel (m/s)	RH (%)	WL_0† (%/d)	k_s F stat	VPL F stat
0.005	50	1.040	29390**	83.6**
	90	0.193	923.4**	78.1**
	95	0.088	210.3**	77.4**
	96	0.066	128.5**	76.7**
	97	0.045	68.0**	76.9**
	98	0.024	26.6**	77.0**
	99	0.003	4.3*	76.8**
	100	−0.018	1.0	76.3**
1	50	1.473	27230**	26.9**
	90	0.257	803.6**	25.6**
	95	0.105	157.7**	25.4**
	96	0.074	89.0**	25.4**
	97	0.044	39.9**	25.4**
	98	0.014	10.3**	25.4**
	99	−0.017	0.01	25.3**
	100	−0.047	8.8**	25.3**
5	50	1.530	25430**	22.3**
	90	0.263	772.4**	21.6**
	95	0.105	146.9**	21.5**
	96	0.073	81.0**	21.5**
	97	0.041	34.8**	21.5**
	98	0.010	7.8**	21.4**
	99	−0.022	0.09	21.5**
	100	−0.054	11.5**	21.4**

*,** Indicates significance at the 0.05 and 0.01 levels, respectively.

† WL_0: Weight loss at lowest k_s and VPL values, 5×10^{-6} and 0.98, respectively.

very high relative humidity for higher air velocity. At 25°C, WL_0 (table 7) ranged from 0.01 to 5.54% per day. Similar trends due to relative humidity and air velocity were found for WL_0 at 25°C, but the magnitude of the changes due to relative humidity and air velocity were greater and no negative weight loss values were predicted. Also, WL_0 at 25°C was always greater than at 5°C, as expected.

Table 7. Predicted weight loss for lowest values of k_s and VPL and F statistics for effect of ks and VPL on predicted weight loss at different air velocities and relative humidities at 25°C

Vel (m/s)	RH (%)	WL_0† (%/d)	k_s F stat	VPL F stat
0.005	50	3.863	48250**	135.9**
	90	1.189	3033**	119.2**
	95	0.857	1492**	117.1**
	96	0.791	1255**	116.7**
	97	0.725	1042**	116.4**
	98	0.659	851.6**	116.2**
	99	0.593	680.8**	115.9**
	100	0.527	530.2**	115.6**
1	50	5.294	36300**	37.4**
	90	1.184	1347**	34.0**
	95	0.671	423.4**	33.7**
	96	0.568	303.5**	33.6**
	97	0.466	204.1**	33.5**
	98	0.364	125.2**	33.5**
	99	0.261	65.7**	33.4**
	100	0.159	25.5**	33.3**
5	50	5.543	30800**	27.7**
	90	1.117	1035**	25.8**
	95	0.564	265.5**	25.5**
	96	0.453	173.3**	25.5**
	97	0.343	101.0**	25.4**
	98	0.232	48.4**	25.4**
	99	0.122	15.0**	25.3**
	100	0.011	0.7	25.3**

*,** Indicates significance at the 0.05 and 0.01 levels, respectively.

† WL_0: Weight loss at lowest ks and VPL values, 5×10^{-6} and 0.98, respectively.

CHANGES IN PREDICTED WEIGHT LOSS DUE TO k_s

The statistical analysis showed all variables to be significant, as expected. It also showed all two way interactions to be significant except VPL × RH, VPL × air velocity, and k_s × VPL. Since the interaction of VPL with temperature and interactions of k_s with temperature, relative humidity, and air velocity were significant, further factorial analysis was performed for the effect of k_s and VPL on predicted weight loss for each temperature, relative humidity, and air velocity combination.

Significant differences among predicted weight loss due to k_s were found for 5°C and all air velocity and relative humidity combinations (table 6), except 0.005 m/s and 100% and 1 or 5 m/s and 99%. As relative humidity and velocity increased, the level of significance of k_s on weight loss decreased. This trend reversed very near saturation (99% RH); where WL_0 became negative, the level of significance of k_s on weight loss increased with relative humidity and velocity.

Similar results were found for predicted weight loss at 25°C (table 7). Significant differences among weight loss due to k_s were found for all air velocity and relative humidity combinations. Also, the significance level of k_s on weight loss decreased as relative humidity and velocity increased. The level of significance of the effect of k_s on predicted weight loss was much higher at 25°C than 5°C.

CHANGES IN PREDICTED WEIGHT LOSS DUE TO VPL

Predicted weight loss at 5°C was significantly different due to VPL at all relative humidity and air velocity combinations. The level of significance of VPL on weight loss decreased as relative humidity and air velocity increased, but only slightly. Results from 25°C were similar to those at 5°C, although the effects of VPL on weight loss had higher levels of significance at 25°C than at 5°C.

Values for k_s and VPL are yet not explicitly known. VPL can be indirectly measured from freezing-point depression, but, as shown, a 1.5% change in VPL can produce significant changes in predicted weight loss, depending on the storage condition. To date, no one has reported measuring k_s, directly. This parameter has been estimated by measuring other model parameters and then using models to back-calculate for a corresponding value of k_s (Chau et al., 1988). Theoretically, values for VPL and k_s can be chosen to obtain model predictions to match measured fruit weight loss.

COMPARISON OF EXPERIMENTAL DATA WITH PREDICTED WEIGHT LOSS

Table 8 shows predicted and average measured weight loss for five peach cultivars (Whitelock et al., 1994) at six storage conditions. Predicted low or high weight loss values were calculated using $k_s = 5 \times 10^{-6}$ and VPL = 0.98 or $k_s = 25 \times 10^{-6}$ and VPL = 0.995, respectively. The predicted weight loss range encompassed the average weight loss for 3 of 5 cultivars at 0 Pa VPD, 4 of 5 at 11 and 37 Pa, 2 of 5 at 148 Pa, and 5 of 5 at 108 and 261 Pa. For each storage condition, the average of the five cultivars' measured weight losses fell within the predicted weight loss range. Also, the predicted weight loss ranges

Table 8. Model predicted and measured weight loss for selected vapor pressure deficits and corresponding temperature/humidity/air velocity conditions

Vapor Pressure Deficit (Pa)	0	11	37	108	148	261
Temp / RH / Air Velocity* (°C) (%) (m/s)	6.3 / 96 / 0+	5.7 / 88 / 0+	6.3/ 96 / 0.5-1.5	5.7 / 88 / 0.7-4.0	4.1 / 68 / 0+	4.1 / 68 / 0.2-1.5
	Weight Loss (S.D.) (%/day)					
Model predicted†						
Low	0.077	0.240	0.093	0.366	0.589	0.903
High	0.191	0.481	0.562	1.832	1.107	4.081
Experimental‡						
'Cresthaven'	0.262 (0.006)	0.450 (0.032)	0.736 (0.062)	0.994 (0.194)	1.274 (0.040)	1.230 (0.028)
'Elberta'	0.213 (0.012)	0.435 (0.015)	0.559 (0.086)	0.873 (0.055)	1.144 (0.099)	1.353 (0.088)
'Loring'	0.162 (0.019)	0.418 (0.011)	0.562 (0.010)	1.101 (0.065)	1.065 (0.014)	1.758 (0.131)
'Ranger'	0.171 (0.006)	0.494 (0.017)	0.521 (0.039)	1.133 (0.088)	1.294 (0.040)	2.127 (0.149)
'Sunhaven'	0.085 (0.020)	0.309 (0.039)	0.433 (0.038)	0.704 (0.124)	0.534 (0.122)	1.325 (0.186)
Average	0.179 (0.062)	0.421 (0.067)	0.562 (0.112)	0.961 (0.191)	1.062 (0.294)	1.559 (0.365)

* 0+ indicates negligible air velocity.

† Weight loss predicted using $k_s = 5 \times 10^{-6}$ and VPL = 0.98 or $k_s = 25 \times 10^{-6}$ and VPL = 0.995 for Low or High, respectively.

‡ Experimental data from Whitelock et al. (1994).

set by varying k_s and VPL over their published values bounded 71% of all the experimental weight loss values. Of the experimental weight loss values that were bounded by the predicted ranges, 60% were at high air velocity and 40% at negligible; 42% were at medium humidity (88% RH) conditions, 33% at low humidity (68% RH), and 25% at high humidity (96% RH). Most (88%) of the values not falling within the predicted weight loss ranges were underpredicted. These results showed that over a wide range of storage conditions the accuracy of weight loss prediction can be enhanced or degraded depending on choice of k_s and VPL.

CONCLUSIONS

Three product parameters had considerable influence on predicted weight loss: skin mass transfer coefficient (k_s), vapor-pressure lowering effect of dissolved solutes (VPL), and radius. The effect of changes in k_s and VPL varied with different storage conditions. Response of predicted weight loss to changes in k_s was nonlinear at low air velocity (0.005 m/s) and nearly linear at high air velocity (5 m/s). Also, predicted weight loss was a linear function of VPL for all storage conditions modeled. Predicted weight loss decreased with increasing relative humidity, became negative near 100% RH, and increased with increasing temperature. Response of predicted weight loss to changes in relative humidity was greater for higher air velocity and temperature. Generally, the effects of k_s on predicted weight loss decreased with increasing relative humidity and air velocity and decreasing temperature. Changes in VPL affected predicted weight loss most at higher temperature, lower velocity, and lower relative humidity. Varying k_s or VPL within their published ranges (5 to 25 × 10^{-6} and 0.98 to 0.995, respectively) caused significant changes in predicted weight loss for 44 or 48 of the 48 storage conditions, respectively. Varying input values of k_s and VPL resulted in predicted weight loss ranges that encompassed 71% of experimental weight loss values for peaches. Experimental weight loss values not falling within the predicted values were mostly (88%) underpredicted.

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