PREDICTION OF POTATO STORAGE LOSSES

by
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Minimizing potato weight loss in storage is one of the primary concerns of people who store potatoes. Annual storage losses in Washington are between 5 and 10%. At current contract prices a weight loss of 10% would cause a 3 to 4 dollar loss per ton.

Weight loss in storage is primarily the result of water loss, so any factor which influences tuber water loss plays a role. It has been known for many years that temperature and relative humidity in the storage are the two most important factors influencing weight loss. High temperatures and low relative humidities result in large losses. (Fig. 1 and 2) A third factor which was recently found to be important is the physical condition of the stored tubers. For example, W. M. Iritani found that "immature" tubers lose weight faster at a given storage temperature than mature tubers. Variety and extent of harvest damage also contribute to storage losses.

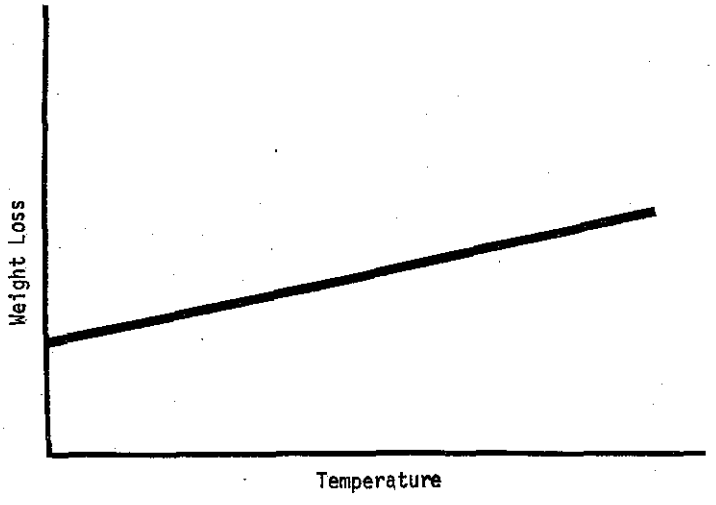

Figure 1. Effect of temperature on weight loss.

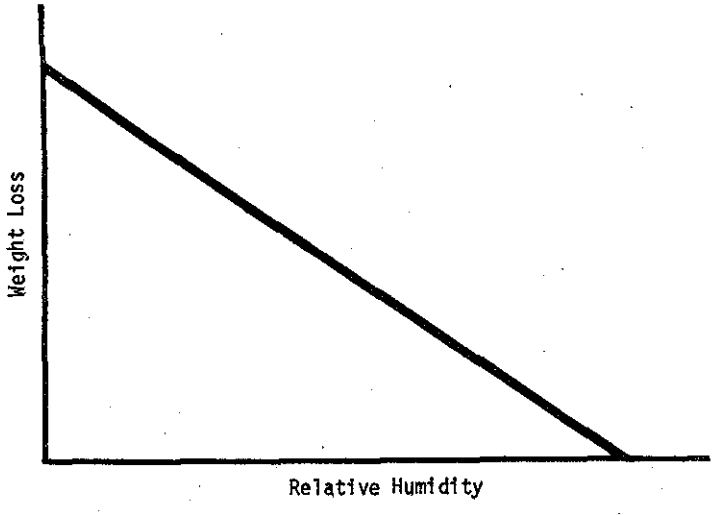

Figure 2. Effect of relative humidity on weight loss.

Storage loss can be conveniently related to three factors by using principles of vapor diffusion in the following expression:

$$\text{Percent loss per day} = k \times C \times (100 - RH)$$

Where C is the concentrations of water vapor in saturated air, RH is the percent relative humidity, and k is the water vapor conductance of the potato skin. The conductance of most mature tuber skins is so low that it controls water loss and we need not consider the conductance of the air around the tuber. The concentration of water vapor in saturated air, also known as saturation vapor density, is strongly dependent on temperature. Table 1 gives values of C x (100 - RH) for various temperatures and relative humidities.

Table 1. Vapor density differences [C x (100 - RH)] in grams/meter^3 x 100

Temp (F)	Relative Humidity									
	0	10	20	30	40	50	60	70	80	90
30	449	404	359	315	270	225	180	135	90	45
35	543	489	435	380	326	272	217	163	109	54
40	655	589	524	458	393	327	262	196	131	65
45	786	708	629	550	472	393	315	236	157	79
50	941	847	752	658	564	470	376	282	188	94
55	1121	1009	897	785	673	561	449	336	224	112
60	1332	1199	1066	933	799	666	533	400	266	133
65	1578	1420	1262	1104	947	789	631	473	316	158
70	1862	1676	1490	1304	1117	931	745	559	372	186
75	2191	1972	1753	1534	1315	1096	877	657	438	219
80	2571	2314	2057	1800	1543	1285	1028	771	514	257
85	3007	2707	2406	2105	1804	1504	1203	902	601	301
90	3508	3157	2806	2456	2105	1754	1403	1052	702	351
95	4081	3673	3264	2856	2448	2040	1632	1224	816	408
100	4734	4260	3787	3314	2840	2367	1893	1420	947	473

As was previously mentioned, the water vapor conductance of the tuber skins depends on variety, maturity, harvest damage, and possibly other factors. It must, therefore, be determined for each lot of potatoes. To determine it we need only determine the percent weight loss per day of a representative sample of tubers and divide this loss by the appropriate factor from Table 1 for the temperature and relative humidity in which the measurements were made. Thus k is given by:

$$k = \frac{\text{percent loss per day}}{C \times (100 - RH)}$$

Once k is known, a measurement of temperature and relative humidity in the storage area will allow calculation of the percent loss per day.

Sample Calculations: Assume you choose a sample of potatoes which initially weigh 2473 grams. You leave these in a room for three days at an average temperature of 70° F and a relative humidity of 30%. (The room should stay within a few degrees of the same temperature over the period of the test and the relative humidity needs to be determined accurately with a sling psychrometer. The lower the relative humidity, the better will be the accuracy of k.) After three days, the tubers weigh 2451 grams.

The percent weight loss is:

$$\frac{2473g - 2451g}{2473g} \times 100 = 0.9\%$$

and the percent loss per day is:

$$\frac{0.9\%}{3 \text{ days}} = 0.3\%/\text{day}$$

Since the relative humidity is 30% and the temperature is 70°F, Table 1 gives C x (100 - RH) = 1304. The value of k is therefore:

$$k = \frac{0.3}{1304} = 0.00023$$

If the RH of the storage was 90% and the temperature 40° F, C(100-RH) (from Table 1) is 65 and the percent loss per day is:

$$kC(100\text{-}RH) = 0.00023 \times 65 = 0.015\%$$

Table 2 shows some percentage losses for typical storage and tuber conditions.

			Loss in 6 Months					
			k = 0.00023			k = 0.0005		
Temp (F)	RH	C(100-RH)	%	$/Ton*	$/5000 Ton	%	$/Ton*	$/5000 Ton
40	90	65	2.7	0.95	4,750	5.9	2.05	10,238
50	90	94	3.9	1.37	6,850	8.5	2.96	14,805
60	90	133	5.5	1.93	9,650	12.0	4.19	20,948
40	80	131	5.4	1.89	9,450	11.8	4.13	20,633
40	70	196	8.1	2.84	14,200	17.6	6.17	30,870
40	60	262	10.8	3.78	18,900	23.6	8.25	41,265

* @ $35.00 per ton

Conclusion

We have shown that storage weight losses in potatoes can be substantial, and that the rate of loss is easily predicted from the principles of vapor diffusion. At present tuber skin conductance must be found experimentally, but as more data accumulates it may be possible to estimate this from tuber maturity, condition, and variety.

Two extensions of these ideas should be pointed out. One is that if the potatoes are to be processed by dehydration, substantial reduction in tuber water content (and thus reduced dehydration costs) might be achieved without significant dry matter loss by lowering the storage relative humidity to maximize percent loss. There is some evidence that slow dehydration over long periods of time

causes the dehydrated product to be gray instead of white. The same equations could be used to determine the length of time required to lose a certain percentage of the tuber water for this calculation. The other idea concerns water loss from seed pieces. When the tuber is cut, the exposed surface has an extremely high conductance so water loss is very rapid unless the pieces are kept at high humidity, covered, and in still air (it is the conductance of the air layer that limits water loss from cut tubers, not the surface conductance). This suggests reasons for the current recommendations on seed handling and storage.

The conductance of the skin of the potato may change during storage. Thus, predictions of weight loss are approximations and should be considered a management tool for storage operations and not as a way of predicting the exact weight of product over long storage periods.