Using Temperature and Humidity as Guides to Curing and Storing Onions
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Cooperative Extension Service
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May 1980
4 pages

For Commercial Growers:

Using Temperature and Humidity as Guides to Curing and Storing Onions

EXTENSION BULLETIN E-1409, MAY 1980, FILE 26.17

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An understanding of the physical principles of dehydration can help you make maximum use of facilities for curing and storing onions in bulk storages. Bulk storage requires, among other things, provisions for drying and cooling the onions so that they can be held for 6 to 8 months after harvest.

This causes considerable confusion, because the removal of water suggests the addition of heat to the onions, whereas, cooling requires the removal of heat. Both cannot be economically achieved simultaneously, so that it is, of course, desirable first to cure the onions properly and then to cool them for long-holding. The problems arise in determining when cooling can be started and in accomplishing it without returning moisture to the onions.

Warm Air for Curing

There are two basic reasons for using warm air for curing. Heat is required for the evaporation of water and warm air carries the heat to the onions where the evaporation takes place. This evaporation requires approximately 1000 B.t.u. of heat to change one pound of water from liquid to vapor. The heat for evaporation will be taken from either the onions or the air. This heat can be supplied by either naturally warmed air from the atmosphere or artificially warmed air.

The second reason for using warm air is that its capacity to hold water is greater than that of cold air. This is shown on the psychrometric chart on page 2. For example, a pound of dry air at 80°F will hold about .022 pound of moisture when it is saturated (relative humidity of 100%), whereas a pound of dry air at 50°F will hold only .008 pound of moisture when it is saturated. If equal volumes of air of 50% relative humidity are supplied for curing onions, the air at 80°F has a moisture carrying potential about three times greater than that of the air supplied at a temperature of 50°F.

When heat is removed from the air by evaporation, the temperature of the air is lowered and consequently its capacity to carry away the resulting water vapor is reduced. This is generally not a problem since a larger volume of air is required to conduct heat to the curing onions than to transport water vapor from the onions.

Relative Humidity

The wet and dry bulb thermometer instrument (psychrometer) used for determination of relative humidity can be used as a guide to onion curing. The ordinary air temperature is read from the dry bulb thermometer. The wet bulb temperature is determined from a similar thermometer supplied with a moistened covering. Evaporation of moisture from the wet bulb causes a drop in temperature in proportion to the rate of evaporation, which depends upon the relative humidity. When both temperatures are known, the relative humidity and moisture content of the air may be determined from the psychrometric chart.

For example, air with a dry bulb of 80° and a wet bulb of 70° has a relative humidity of about 60% and a moisture content of .013 pound of water for each pound of dry air. A temperature change may occur without any change in the actual moisture content of the air, but it will change the relative humidity. To show this we will assume the dry bulb temperature drops from 80° to 70° and moisture is neither added to nor removed from the air during cooling. In this case, the wet bulb temperature would fall to 67° and the relative humidity would change from 60% to about 85%. Upon further cooling of the air without a change in moisture content, the relative humidity would increase and 100% would be reached at a temperature of about 65°. At this point, the wet and dry bulb temperatures would be the same. Since the air is now saturated with moisture, still further cooling would cause a loss of moisture from the air and condensation would take place.

Water Losses

You can determine whether moisture is being removed from onions or other materials during the drying process by comparing the moisture contents of the air entering and leaving the curing room. The amount of moisture gain or loss can be calculated when the volume of air being moved through the material is also known.

The following examples show how the wet and dry bulb temperatures may be used in conjunction with the psychrometric chart (below) to determine the curing capacity of the air:

Example 1. The air supplied to the onions has a dry bulb of 80° and a wet bulb of 60°F. On the chart, the vertical lines represent the dry bulb temperatures and the diagonal straight lines the wet bulb temperature. The vertical line from 80 intersects the diagonal line (60° W.B.) at point A. The curved line near point A shows the relative humidity of the supply air is about 30%. If the horizontal line through point A is extended to the far right to point B, it is seen that this air contains about .007 pound of water for each pound of dry air.

At the same time, the air exhausted from the curing room has a dry bulb of 75°F and a wet bulb of 70°. This air has a relative humidity of 78% (point C) and contains about .015 pound of water per pound. Each pound of air supplied has gained about .008 pound of water from the onions. Under these conditions, 1000 cubic feet of air weighs approximately 72.4 pounds; therefore, 1000 cubic feet of air will carry away almost .6 pound of water.

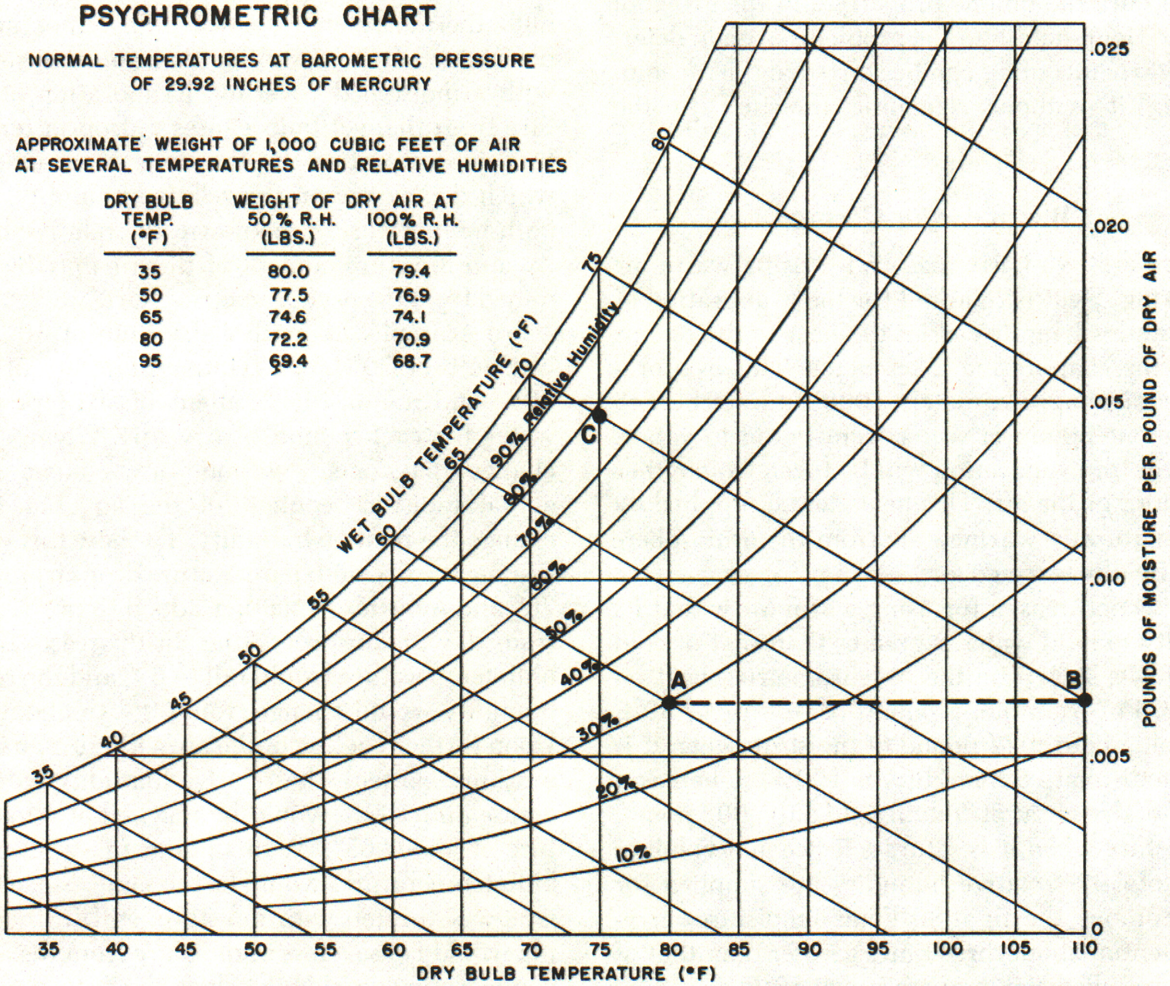
Example 2. Air is supplied at a temperature of 70° dry bulb, 60° wet bulb; the relative humidity is 56% and the moisture content is .009 pound per pound of air.

PSYCHROMETRIC CHART

NORMAL TEMPERATURES AT BAROMETRIC PRESSURE OF 29.92 INCHES OF MERCURY

APPROXIMATE WEIGHT OF 1,000 CUBIC FEET OF AIR AT SEVERAL TEMPERATURES AND RELATIVE HUMIDITIES

DRY BULB TEMP. (°F)	WEIGHT OF DRY AIR AT 50% R.H. (LBS.)	100% R.H. (LBS.)
35	80.0	79.4
50	77.5	76.9
65	74.6	74.1
80	72.2	70.9
95	69.4	68.7



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Air is exhausted at 68° dry bulb, 65° wet bulb; the relative humidity is about 86% and the moisture content is .012 pound. Each pound of air supplied (on the basis of the weight of dry air) is removing .003 pound of water.

The above examples could occur whenever the onions are of a lower temperature than the air used for curing purposes. The temperature drop of the air passing through the curing room would be due to the transfer of heat from the air to the onions and to the use of heat in the evaporation of water.

Condensation

It is sometimes noted during the curing period that the onions at the top of the bulk pile become moistened when they are receiving the forced air treatment. This could occur when the air is supplied at a dry bulb temperature only slightly above the onion temperatures, and is exhausted at a wet bulb temperature the same as the temperature of the onions at the top of the pile. Under these circumstances, the supplied air is picking up moisture from the lower depths of onions and thereby loses heat. Upon further contact with the slightly cooler onions as it is forced up through the pile its temperature is further lowered to the point that some water is precipitated on the onions. Continual air movement through the onions should soon correct this condition, however.

Serious difficulty during curing would arise when relatively cool onions (for example, at a temperature of 60°) are exposed to warm air with a high relative humidity, such as a wet bulb temperature of 79° and a dry bulb temperature of 75°F. When this warm, humid air is cooled below 68° as a result of contact with the onions, it will deposit water on the onions. If, for instance, this air is cooled to 65°F, it will hold only .013 pound of water per pound of air, whereas, originally it contained about .016 pound of water per pound of air. Water, amounting to .003 pound for each pound of supplied air, will be deposited on the onions. The reason for this condensation on the onions is the same as for the condensation of moisture on the outside of a cold glass of water on a hot summer day. It occurs whenever the air is cooled below the point at which it becomes saturated with water vapor.

There is no danger of condensation when both the wet bulb and dry bulb temperatures of the supplied air are lower than the temperature of the onions. As this air is warmed by contact with the onions, its capacity to hold water increases and the saturation point will not be reached. If it picks up heat from the onions without taking on additional water, its wet bulb temperature will also increase, but not as much as the dry bulb temperature.

Recommendations

CURING:

1. The amount of moisture in the air exhausted from the curing chamber should always be higher than in the air supplied for curing purposes. The amount of moisture can be readily determined with a psychrometric chart when the wet and dry bulb temperatures are known.
2. The wet bulb temperature alone may be used only as a general guide to curing. In such cases, the wet bulb temperature of the exhaust air usually should be higher than the wet bulb temperature of the supply air, and it usually should be slightly lower than the temperature of the onions.

STORAGE:

1. The dry bulb temperature alone can be used as an index of cooling. For this purpose, the supply air should have a lower temperature than the onions, and the exhaust air should be warmer than the supplied air.
2. The wet bulb temperature of the exhaust air should also rise during the cooling process even though no further drying of the onions is taking place. The rise in the wet bulb temperature usually will be smaller than the rise in the dry bulb temperature.
3. The recommended storage conditions for onions are a temperature of 32°F, and a relative humidity of 70 to 75%.

Equipment

Accurate, yet simple and relatively inexpensive, instruments are available for measuring the moisture conditions of the air for onion curing and storage purposes. These psychrometers consist of two thermometers, one of which has a wick to be moistened, that are mounted together to give the wet and dry bulb temperatures. A hand operated sling psychrometer is mounted on a swiveled handle and can be used wherever there is adequate room to swing it freely. Other types, some of which include a power-driven fan, which passes the air over the sensing portion of the two thermometers, can be used within areas of limited space.

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O-12179