• ARTIFICIAL CURING OF
• Texas Onions

Experimental gas-fired infrared onion drier.

TEXAS AGRICULTURAL EXPERIMENT STATION
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IN COOPERATION WITH THE U. S. DEPARTMENT OF AGRICULTURE
SUMMARY

The several methods of artificial curing of onions tested were forced air drying, forced heated-air drying, electric infrared radiation, ultraviolet light and gas-fired infrared radiation.

Favorable results with some limitations were obtained with all methods tried with the exception of ultraviolet light.

Forced air and forced heated-air drying are proving effective in commercial usage in South Texas. The disadvantages are the long treatment period, 12 to 24 hours, the double handling of field-bagged onions and the high fuel costs.

Gas-fired infrared radiation appears promising as a commercially adaptable forced-curing treatment for onions. The advantages would be the short treatment period, 3 to 4 minutes, the continuous flow of onions through the packing line and the relatively low operating costs.

Common onion storage is especially adapted to the Winter Garden area of Texas, where low rainfall and humidity prevail during the spring and summer. At Crystal City, artificially cured onions were held successfully in common storage in a rodent and insect-proof, well-roofed, screen-walled building for 70-day periods.

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Texas is among the leading states in onion production. Most of the crop is produced in South Texas and is marketed within a 3-month period in the spring. The Bermuda type onion, a variety of relatively poor keeping quality, constitutes the main part of the crop. The successful marketing of the Texas onion crop is subject to a number of factors. The price level is affected directly by the supply of onions from Northern States remaining in storage and the volume of foreign import shipments of new onions. Even with these two factors in a favorable position for the profitable marketing of Texas onions, prevailing weather conditions may become the limiting factor. The normal harvesting operation includes 1 to several days of field drying, during which time the tops and roots are removed. If conditions are favorable generally for field curing, the market often becomes unstable from heavy shipments. In contrast, if inclement weather stops the harvesting operation, growers and shippers are unable to participate in the high price market resulting from the short supply.

The Texas Agricultural Experiment Station and the Agricultural Marketing Service of the U. S. Department of Agriculture have conducted a cooperative investigation to develop methods for extending the marketing period of onions. The objective of this investigation has been a satisfactory forced-curing method that would improve the storage quality of the Bermuda onion and also make harvesting possible during periods of inclement weather.

A relatively short storage period of 1 to 2 months would prolong the marketing of Texas onions sufficiently to alleviate a temporary market glut. Refrigerated and common storage were compared in these tests. The latter is less expensive and, if feasible, could be used by the individual growers in areas of prevailing low relative humidity.

**PROCEDURE**

**Fungicidal Chemical Treatments**

Since gray-mold neck-rot disease caused by *Botrytis allii* Munn. is probably the most destructive disease of onions in storage and transit, experiments were initiated in an attempt to control the *Botrytis* fungus in the field and thereby minimize the problem of neck-rot disease in storage.

Various fungicides including maneb, zineb, captan and nabam were applied as sprays to experimental field plots of onions and as post-harvest treatments before storage. Nabam fungicide also was incorporated into irrigation water at several concentrations and to the harvested onions prior to storage. The onions were examined at 30-day intervals during the storage period and the decay was recorded.

**Inoculation Procedure**

A procedure was devised to insure development of gray-mold neck-rot disease in test onions in storage and to provide a reliable basis for the evaluation of pre-storage curing treatments.

Freshly harvested onions with 2 to 3-inch necks were obtained. In the laboratory, the necks of the onions were re-clipped and the fresh cut tissue on each onion inoculated with a water suspension of approximately 25,000 spores of the gray-mold neck-rot fungus. The onions were incubated at room temperature for 24 hours before exposure to curing treatments. In the curing tests other than with forced (unheated) air drying, where onions with only natural infection were used, 22 or 50-pound replicated lots of inoculated onions were used.

**Forced Air Drying**

The forced air drying was done in a small, semi-closed chamber capable of holding four 25-pound bags of onions. Outside air was forced into the chamber by a blower fan with a rated capacity of 1,500 c.f.m. The bags were supported on racks which provided free air circulation around each bag, a condition probably not obtainable in commercial practice. The onions were weighed at the start and end of 24 and 72-hour continuous and intermittent treatment periods. The relative humidity of the incoming and outgoing air was recorded at regular intervals.

**Forced Heated-air Drying**

The forced air drying was done in a small, semi-closed chamber capable of holding four 25-pound bags of onions. Outside air was forced into the chamber by a blower fan with a rated capacity of 1,500 c.f.m. The bags were supported on racks which provided free air circulation around each bag, a condition probably not obtainable in commercial practice. The onions were weighed at the start and end of 24 and 72-hour continuous and intermittent treatment periods. The relative humidity of the incoming and outgoing air was recorded at regular intervals.
lots of onions were maintained in all experiments. Incident of decay was recorded at 30-day intervals during the storage period.

**Electric Infrared Radiation**

The inoculated onions were placed on a 3/4-inch mesh wire tray between an upper and lower bank of 250-watt R40 infrared lamps in a closed treating chamber. Radiation exposure periods were 6 to 9 minutes. After treatment, the onions were placed in common and refrigerated storage and examined at 30-day intervals for the incidence of gray-mold neck-rot decay.

**Ultraviolet Light**

To determine the effects of ultraviolet light as an additive treatment in the curing process, test onions were irradiated with ultraviolet light alone and in combination with infrared radiation for an exposure period of 3 minutes. The treated onions were stored and evaluations made as described.

**Gas-fired Infrared Radiation**

A “Schwank” gas-fired 48,000 BTU infrared radiant heater operating on propane fuel at 11 inches water column was used in these experiments. The inoculated onions were placed on a 3/4-inch mesh wire tray under the Schwank infrared radiant heater and irradiated at 200, 250, and 300°F. for 1/2, 3, and 6 minutes. Air temperatures were determined by a blackened bulb thermometer. Onion temperature 1/4 inch under the skin was recorded by means of a thermocouple for each exposure period. The irradiated onions were placed in both types of storage and examined for incident of decay at 30-day intervals.

**RESULTS**

**Fungicidal Chemical Treatments**

Because of the erratic results obtained in 2 years’ testing with the various fungicides used in pre-harvest applications to onions, further experimentation was discontinued.

**Forced Air Drying**

Onions which had been field-cured under favorable conditions lost an additional 1.3 and 1.8 percent in weight, respectively, during the 24 and 72-hour continuous blower operation. The relative humidity readings of the incoming and outgoing air indicated that no drying occurred during the night. This was confirmed by comparing 72-hour continuous blower operation with 27-hour intermittent operation during the daylight hours of the 3-day treatment period. The latter treatment resulted in a slightly greater weight loss in freshly harvested onion, showing that forced drying with normal air is most effective in daylight hours in clear weather when the relative humidity is comparatively low.

**Forced Heated-air Drying**

Forced heated-air drying of onions at a temperature of 116 to 118°F. for 4 hours was a satisfactory post-harvest treatment. Gray-mold neck rot was controlled effectively in the inoculated bulbs for 4 weeks in common storage and for 8 weeks in refrigerated storage, after which the incidence of neck rot gradually increased. At the end of the 20-week common storage period and the 24-week refrigerated storage period, the decrease in decay was slight, Figure 1. Drying periods longer than 4 hours were even more effective. Onion weight losses resulting from forced heated-air drying varied somewhat with the

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Days in storage</th>
<th>Decay developed during storage, %</th>
<th>Weight loss during storage, %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Common</td>
<td>Refrigerated</td>
</tr>
<tr>
<td>Infrared</td>
<td>30</td>
<td>5.0</td>
<td>0</td>
</tr>
<tr>
<td>(6 minutes)</td>
<td>60</td>
<td>10.0</td>
<td>0</td>
</tr>
<tr>
<td>(6 inches)</td>
<td>67†</td>
<td>12.0</td>
<td>4.0</td>
</tr>
<tr>
<td>Ultraviolet</td>
<td>30</td>
<td>35.0</td>
<td>0</td>
</tr>
<tr>
<td>(3 minutes)</td>
<td>60</td>
<td>90.0</td>
<td>39.0</td>
</tr>
<tr>
<td>(3 inches)</td>
<td>67†</td>
<td>99.0</td>
<td>96.0</td>
</tr>
<tr>
<td>Infrared</td>
<td>30</td>
<td>4.0</td>
<td>0</td>
</tr>
<tr>
<td>(6 minutes)</td>
<td>60</td>
<td>12.0</td>
<td>0</td>
</tr>
<tr>
<td>(6 inches) plus ultraviolet</td>
<td>67†</td>
<td>14.0</td>
<td>5.0</td>
</tr>
<tr>
<td>(3 minutes) (3 inches)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Check—no treatment</td>
<td>30</td>
<td>41.0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>60</td>
<td>96.0</td>
<td>59.0</td>
</tr>
<tr>
<td></td>
<td>67†</td>
<td>97.5</td>
<td>98.0</td>
</tr>
</tbody>
</table>

†Test lots were held 7 days at room temperatures after 60 days in refrigerated storage (33°F.)
Effect of post-harvest infrared radiation and forced heated-air curing on the incidence of decay of onions in common and refrigerated storage. All onions were inoculated with the gray-mold neck-rot disease fungus before the curing treatments.

Individual test lots. Onions receiving no prior field drying generally showed losses ranging from 2 to 3.5 percent, respectively, from the 4 and 24-hour treatments. The maximum 24-hour exposure caused no heat injury to the bulbs.

Electric Infrared Radiation

The first experiments using R40 infrared lamps to cure onions rapidly showed much promise from the standpoint of drying and reduction of gray-mold neck-rot disease in storage. The degree of control of gray-mold neck rot in inoculated bulbs obtained with the 9-minute exposure to infrared lamps was comparable with that resulting from the 4-hour exposure to heated air, Figure 1. The exposure period was reduced to 6 minutes in later experiments using a 6-inch spacing from infrared lamps to onion bulbs. Excellent control of gray-mold neck-rot disease in the stored onions was obtained with 6 minutes drying time. As shown in Table 1, 4 and 12 percent decay occurred in test onions in refrigerated and common storage, respectively, compared with 98 and 97 percent decay in the two control lots.
during the 67-day storage period. Pre-storage weight losses from infrared radiation never exceeded 1 percent. Heat injury in the form of shallow, sunken areas in the outer scales developed on onions directly under the infrared lamps. However, onions moving and rotating on a brush conveyor would not be subject to such damage.

**Ultraviolet Light**

Since infrared radiation does not markedly control the bacterial soft-rot organism, onions were irradiated with ultraviolet light alone and in combination with infrared to determine any additive effects ultraviolet light may have in the drying of onions and the control of gray-mold neck-rot and bacterial soft-rot disease. As indicated in Table 1, ultraviolet radiation alone was not effective in controlling the gray-mold neck-rot fungus; nor was there any indication of additional control of bacterial soft rot when ultraviolet and infrared radiation were combined.

**Gas-fired Infrared Radiation**

The results of onion storage tests in which the bulbs were irradiated with gas-fired infrared as a pre-storage treatment were encouraging. A marked reduction in the incidence of gray-mold neck rot in inoculated bulbs was obtained by the 3-minute 250°F treatment. As shown in Table 2, 12 and 22 percent decay occurred in tested onions during 70 days common and refrigerated storage. This compares with 98 and 74 percent decay, respectively, which developed in the two control or check lots held under the same storage conditions.

The gas-fired infrared treatment compared favorably with the electric infrared in the control of gray-mold neck rot in inoculated bulbs. A more important factor was the reduction of the treatment period to 3 minutes compared with 6 minutes for the electric source of infrared, which would make gas-fired infrared radiation more adaptable for use in an onion-packing operation. In addition, the shorter treatment period practically eliminated heat injury even though the bulbs were stationary.

**DISCUSSION**

In these tests with different artificial curing treatments, four methods proved successful in small-scale application: (1) forced air drying; (2) forced heated-air drying; (3) electric infrared radiation; (4) gas-fired infrared radiation.

Both forced air and forced heated-air drying have been used on a commercial scale by a few shippers in Texas since 1958. Converted citrus degreening rooms and specially constructed semi-open walled bins are used. The capacity of either is about 1,500 field bags of onions arranged in tight solid layers, 5 bags high, over the entire floor area. Both are equipped with slatted false floors which are connected by an air duct to a thermostatically controlled blower-heater. This arrangement allows the shipper to force-cure either with heated or unheated air, depending on prevailing weather conditions. The more effective curing is obtained with heated air. Onion weight losses up to 3 percent can be expected with a 14-hour treatment with the air blast temperature more than 120°F. When unheated air is used, a 24-hour treatment results in about a 1 percent weight loss. The disadvantages of both types of forced air curing are double handling of field-bagged onions, the irregular flow of onions through the packing operation and the somewhat limited volume that can be handled. Forced (unheated) air curing is further limited by inclement weather conditions and daytime operation.

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**TABLE 2. EFFECT OF GAS-FIRED INFRARED RADIATION AS A POST-HARVEST CURING TREATMENT OF GRAY-MOLD NECK-ROT DISEASE IN INOCULATED ONIONS HELD IN COMMON AND REFRIGERATED STORAGE**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Onion temp. (°F)</th>
<th>Decay developed during storage, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exposure period, minutes</td>
<td>Temp. (°F)</td>
<td>Common, 70 days</td>
</tr>
<tr>
<td>1 1/2</td>
<td>200</td>
<td>75.5</td>
</tr>
<tr>
<td>3</td>
<td>200</td>
<td>72.8</td>
</tr>
<tr>
<td>6</td>
<td>200</td>
<td>80.4</td>
</tr>
<tr>
<td>1 1/2</td>
<td>250</td>
<td>86.6</td>
</tr>
<tr>
<td>3</td>
<td>250</td>
<td>85.2</td>
</tr>
<tr>
<td>6</td>
<td>250</td>
<td>84.3</td>
</tr>
<tr>
<td>1 1/2</td>
<td>300</td>
<td>82.6</td>
</tr>
<tr>
<td>3</td>
<td>300</td>
<td>82.6</td>
</tr>
<tr>
<td>6</td>
<td>300</td>
<td>79.9</td>
</tr>
</tbody>
</table>

Check—no treatment | Room temp. | 73.0 | 87.0 | 93 | 42 | 74 |

Footnotes:
1. Temperature 1/4-inch depth.
2. Test lots were held 7 days at room temperatures after 63 days in refrigerated storage (33°F).
Infrared radiation, both the electric or gas sources, will cure onions more rapidly than any of the other methods tested. The use of infrared radiation has a particular advantage over the conventional type of forced heated-air drying in that it is little affected by atmospheric moisture, since an outside source of air is not used. The onion bulbs absorb the radiant energy and surface moisture is rapidly dissipated, leaving the outer scales of the irradiated onions dry.

In addition to being a rapid and effective post-harvest curing treatment, infrared radiation also is effective as a post-storage treatment for the rapid dissipation of moisture condensation from the surface of onions upon removal from refrigeration and after reaching room temperature.

Infrared radiation was particularly effective in the reduction of the incidence of gray-mold neck-rot disease in bulbs which had been inoculated prior to treatment. However, infrared radiation had little, if any, effect in the control of bacterial soft rot resulting from field infection. Likewise, no control of surface molds on onions in film bags was obtained by treatment with infrared before packaging.

Infrared radiation for the rapid curing of onions has considerable potential to the onion industry. The advantages of this method would be the short treatment period, 3 to 4 minutes, and the continuous flow of onions through the packing operation, thus eliminating double handling of field-bagged onions.

One possible application would involve a brush conveyor carrying one layer of onions progressively along under a battery of gas-fired infrared heaters suspended overhead. The conveyor necessarily would have to be of sufficient length and properly geared to keep the onion under the heaters for 3 minutes. The conveyor brushes would have to be heat-resistant to withstand the high operating temperature. With such equipment available “to take over” during periods of inclement weather, the movement of onions to markets could be continued with but little reduction in volume.
State-wide Research

The Texas Agricultural Experiment Station is the public agricultural research agency of the State of Texas, and is one of ten parts of the Texas A&M College System.

Organization

In the Main Station, with headquarters at College Station, are 16 subject-matter departments, 2 service departments, 3 regulatory services and the administrative staff. Located out in the major agricultural areas of Texas are 21 substations and 9 field laboratories. In addition, there are 14 cooperating stations owned by other agencies. Cooperating agencies include the Texas Forest Service, Game and Fish Commission of Texas, Texas Prison System, U. S. Department of Agriculture, University of Texas, Texas Technological College, Texas College of Arts and Industries and the King Ranch. Some experiments are conducted on farms and ranches and in rural homes.

Operation

The Texas Station is conducting about 400 active research projects, grouped in 25 programs, which include all phases of agriculture in Texas. Among these are:

- Conservation and improvement of soil
- Conservation and use of water
- Grasses and legumes
- Grain crops
- Cotton and other fiber crops
- Vegetable crops
- Citrus and other subtropical fruits
- Fruits and nuts
- Oil seed crops
- Ornamental plants
- Brush and weeds
- Insects
- Beef cattle
- Dairy cattle
- Sheep and goats
- Swine
- Chickens and turkeys
- Animal diseases and parasites
- Fish and game
- Farm and ranch engineering
- Farm and ranch business
- Marketing agricultural products
- Rural home economics
- Rural agricultural economics
- Plant diseases

Two additional programs are maintenance and upkeep, and central services.

Research results are carried to Texas farmers, ranchmen and homemakers by county agents and specialists of the Texas Agricultural Extension Service.