Station Bulletin 205 May, 1924

Oregon Agricultural College

Experiment Station

Drying Prunes in Oregon

By

Ernest H. Wiegand

CORVALLIS, OREGON

BOARD OF REGENTS OF THE OREGON AGRICULTURAL COLLEGE AND EXPERIMENT STATION

STATION STAFF

Drying Prunes in Oregon*

By

ERNEST H. WIEGAND

The growing conditions of Oregon are peculiarly adapted to many varieties of prunes. The French prune, commonly known as the petite, and the date prunes are chief among the sweeter varieties commercially grown. The more tart prune, the Italian prune, however, is the most common of Oregon prunes.

The first Italian prune stock entered Oregon about 1857. It is known as the Fallenberg prune and came originally from Europe. There is a large acreage of this variety of prune in the Pacific Northwest.

At the present time more care should be given to the orchards already planted. Any increase in acreage could well be sacrificed for this end. It is far better to have a shortage of high grade prunes than an excess of poor quality stock.

Orchard investment is permanent. Large sums of money are involved in the growing of an orchard; in cost, upkeep, and depreciation of orchard equipment; and in construction of a dryer and operating machinery.

EVOLUTION OF THE EVAPORATOR

One of the most interesting and involved phases of the prune history is that of types of evaporators. Years ago it was realized that a more uniform product was needed, and the only way to obtain such was in the proper construction of the drier. As Hedrick† put it: "The importance of the erection of evaporating plants, and more efficient management of them can hardly be estimated. A good evaporator is the prime essential to success—if for no other reason than that there is at present such a wide range in quality and style of product that it has no established place on the markets."

Even as recently as a year or two ago, it was recommended to an inquirer who desired to build an evaporator that he visit and inspect the various driers in the state or elsewhere, and from them conclude the best type to build. Such was the best that could be done since the experimental work on the real factors that should dictate the construction of the drier had just begun.

Few other fields have offered as great an opportunity for mechanical ingenuity as the field of dehydration. Literally hundreds of types of driers have been built with every possible turn of construction to accomplish the desired end. Starting from the hop kiln in its almost startling simplicity, there existed as early as 1897 such complicated structures as the Penniman evaporator.

---

*With a view to determining the effect of various pretreatments, drying temperatures, and humidities on the rate of drying and the quality of dried Italian prunes, a series of experiments was carried out at this Station in collaboration with Ray Powers of the Bureau of Chemistry, United States Department of Agriculture. These experiments covered a wide range of temperatures and humidities and were under carefully controlled conditions. The data presented and the conclusions drawn in this bulletin are the result of this work.

†Prunes in Oregon. Oregon Agricultural Experiment Station Bulletin 45.

PRINCIPLE SIMPLIFIED

The fundamental principle sought at that time for the most successful drying is present today in a much simpler and more efficient mechanical form, that of moving the air over the fruit instead of moving the fruit through the air. Because of its cheapness and simplicity, and the need for a small capacity evaporator, the natural-draft drier took precedence over the mechanical draft, following an order of evolution from the hop kiln to the box evaporator which contained the fruit on trays instead of the floor. Then came a modification by changing the source of heat to steam pipes just under each tier of trays.

In the Carson evaporator the floor opened the full length, and permitted the hot air from the furnace chamber to pass through the trays placed on sloping tray racks. This approaches in a way the horizontal type, as did the Allen evaporator which through various modifications has come down to the present time as the Oregon tunnel.

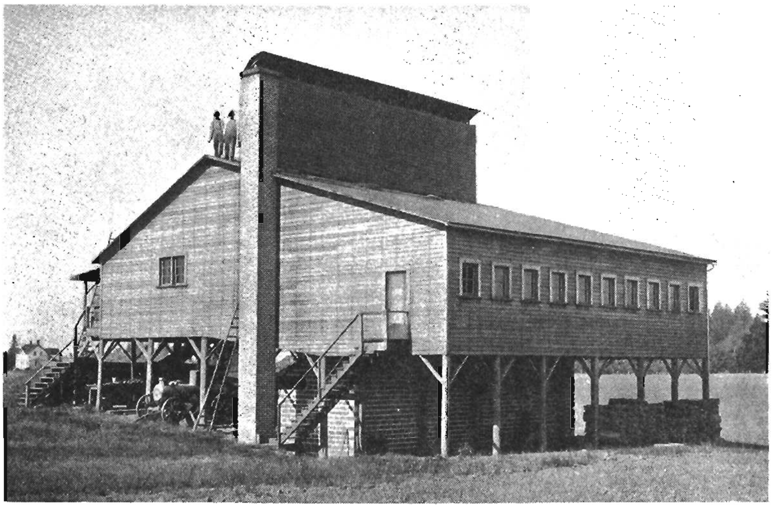


Fig. 1. Oregon tunnel drier, C. R. Widmer, Albany.

The superior method of drying by mechanical draft has been the only method possible to use in Oregon, but for various reasons has not received, until recently, the proper scientific attention to harness its great potential powers for accomplishing the production of a superior product. In fact, with the admission of the failure to establish a sound and uniform basis of drying has come the desire, with moral and financial backing, for proper scientific work.

These brief opening remarks are intended to show that there is nothing new in the principle of dehydration; but that there must be an awakening to recognized needs.

Care for the orchard properly, work for a high-quality product in so far as best effort will allow, and be keenly alert to all improvements that are advanced. This will insure in the near future an excellent standardized product.

STANDARDIZATION

There is nothing better than the best, and the best is in demand. Italian prunes will be a source of prosperity to the people of the state just to the extent of the market demand, which is primarily dependent on quality. A standard product is a guaranteed-quality product. Brokers, commission men, wholesalers, retailers, and consumers all call for a product which retains its identity from year to year. Once this is achieved there can be no separation of the prune from its quality and the market demand will continue.

For natural quality the dried Oregon prune has a decided advantage. It has the basic elements of a mild, aromatic tartness and a high percent of sugar from which to produce artificially and maintain an excellent product in popular demand.

The importance of standardization and economical production must be recognized in all the steps in the production of a dried prune. For the purpose of the present discussion, we will recognize five steps:

1. Sanitation in handling.
2. Growing and harvesting the fruit.
3. Preparing the fruit.
   - (a) Grading.
   - (b) Dipping.
   - (c) Traying.
4. Drying.
5. Processing and packing.

SANITATION

Sanitation is part of standardization. Several generations have passed since commercial canning and drying began, and still there remains a passing hesitancy on the part of the consumer to eat dried products. No doubt there was ample reason in the early days for this hesitancy or refusal to use the commercially prepared foods. With our modern methods, there should be reason now for using the dried and canned products as greater care is taken in all the steps of food production.

The artificially dried prune has every chance possible to be, if you might so term it, "ultra-sanitary." This would require only ordinary care from the time the prune is picked to its final placing in cartons or boxes for shipment.

Sanitation should start in the field. All boxes used should be clean, and the pickers should be constantly warned against putting rotten or moldy fruit with the good. This will insure the prune in the best condition for delivery to the drier.

It is often required, and very rightly so, that all fruits or vegetables in transit to the drier be covered to prevent the road dust from settling on the exposed surface. Even with these precautions, however, the prune should be washed before it is placed in the drier. This step is very important. If lye solution dipping is not used, boiling or hot water should be used, and in either case there should be a rinsing in cold water. Especially should this be very thorough with the lye-dipped product.

Holding the prunes in the lug boxes should be avoided. It is a difficult but important part of drier management to have the fresh fruit out of the lug boxes and into the drier within twelve to twenty-four hours. Lack of tunnel capacity to care for the crop is a very great handicap in drying a high-quality sanitary prune.

All precaution thus far taken would be of little worth if the dried product were permitted to come in contact with dirt and dust before being packed. All storage bins should be covered, and care should be taken in handling the fruit. Only helpers who are clean in their habits and careful in their work should be employed.

GROWING AND HARVESTING

Methods of orchard practice such as selecting a site, cultivating, pruning, and harvesting are not within the scope of this bulletin, but a brief word will at least properly emphasize the importance of good condition of the fresh fruit to insure a superb dried product.

Fig. 2. Italian prunes ready for first picking.

A high-quality prune must have plenty of moisture and be as near ripe as possible at picking time. Some authorities claim that the red prune is due to lack of plant food, others that it is because of too little moisture, or that it may be due to the stage of maturity.

It is of utmost importance that the prune be brought to the drier as a first-class, ripe, fresh fruit if it is desired to obtain a high-quality dried product.

Lug boxes are very much in evidence around the drier during the harvesting of the prune. Much can be said for and against the use of the large lug or field box in handling prunes from the orchard to the drier. This box, holding on the average sixty pounds of fresh fruit, is unwieldly and unsanitary, causing the fruit to mash, besides promoting the development of brown-rot *(Sclerotinia ceneria)* in case the fungus is present. The use of the small lug box commonly used in California would in a greater measure reduce the loss, especially in wet years when the brown-rot is more prevalent and the fruit becomes soft before harvesting. Less bleeding and over-heating would occur at the drier if the fruit were allowed to remain in this type of orchard box.

The quality of the prune cannot be raised above the condition of the fruit as it is trayed for drying. If the fruit is mashed, sour, or moldy, it will dry as such, or if it is in a soft condition, trayed and left standing (for want of tunnel capacity), it will mold much more quickly than the firm fruit.

PREPARING THE FRUIT

Grading. Grading before drying has been practiced to some extent in the past. Although there is merit in the procedure, certain points of disadvantage have not permitted definite conclusions. The difficulty lies in the kind of machine used as most types tend to mash or skin the fruit, doing as much damage as good. There are two types on the market; the protected roller type which gradually widens, dropping the fruit according to size, and the shaker type with holes, grading from smaller to larger. As it is recommended that the fruit be picked at the ripe stage, grading would hardly be feasible in such cases because of mashed and bruised fruit.

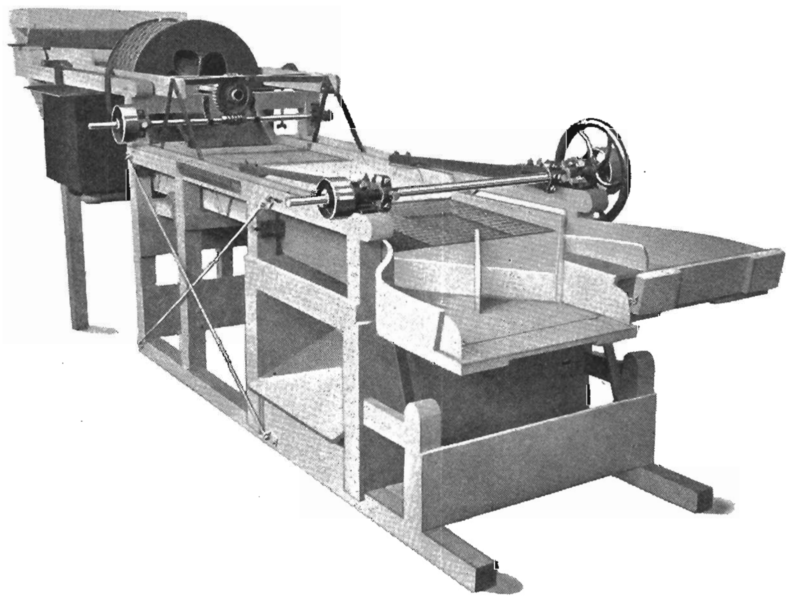
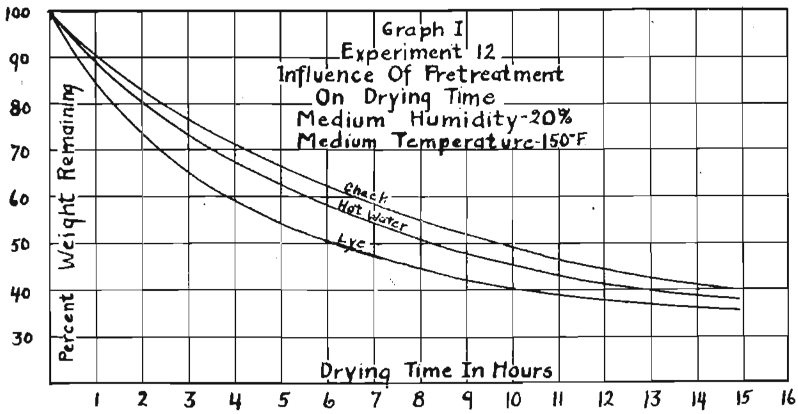


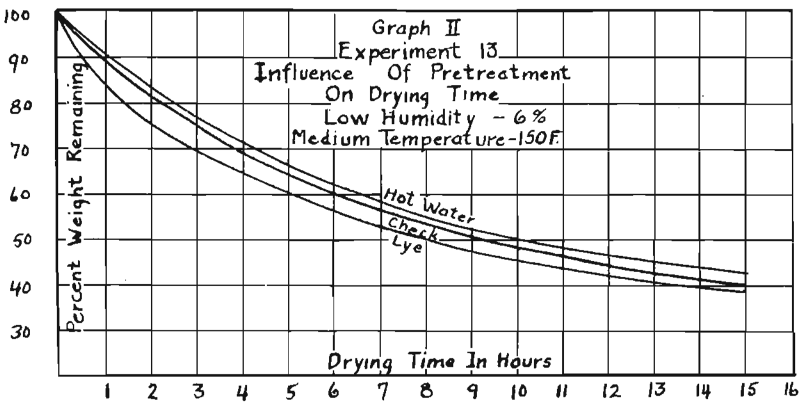
Fig. 3. Shaker type grader and perforator. (Courtesy Anderson Barngrover Mfg. Co.)

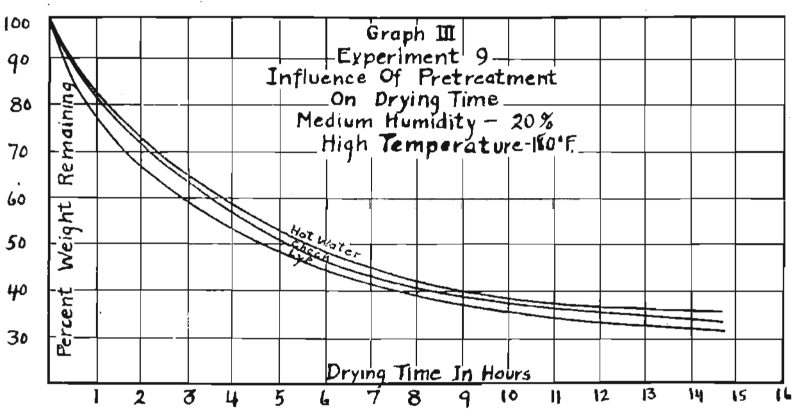
Much of the difficulty in uneven drying is due no doubt to the mixed sizes of the fresh fruit. This difficulty may be reduced by increasing the circulation with lower temperatures and higher humidity. This has been indicated by the first season's work on the proper relation of the factors, temperature, humidity, and circulation.

It might be further added that in the natural-draft tunnel, there is invariably a lack of uniform drying on the trays because of air pockets and channeling which would make useless a sizing of the fruit before traying.

Dipping. The Italian prune, covered with a rather impervious, waxy skin, has been pretreated at various times and in various ways for the

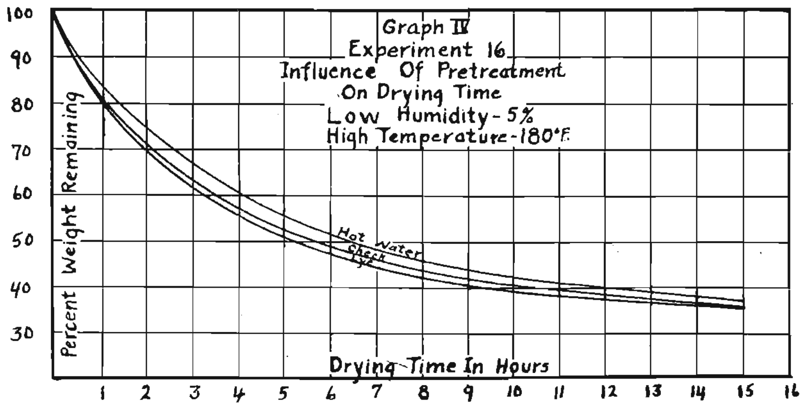

Graph I
Experiment 12
Influence Of Pretreatment
On Drying Time
Medium Humidity-20%
Medium Temperature-150°F
Check
Hot Water
Lye
Percent Weight Remaining
Drying Time In Hours
100
90
80
70
60
50
40
30
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

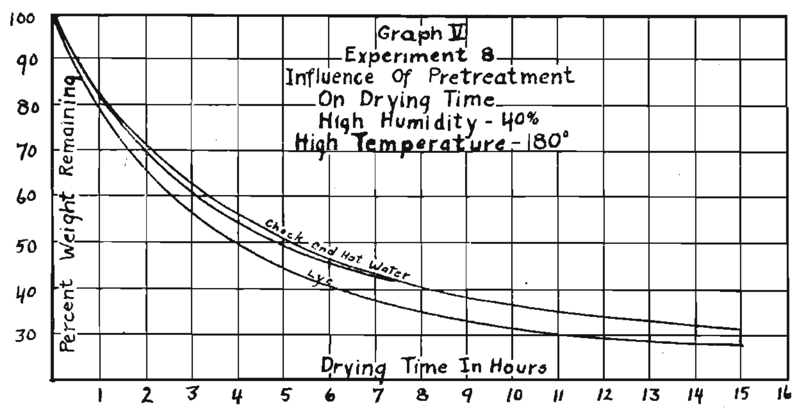

Graph II
Experiment 13
Influence Of Pretreatment
On Drying Time
Low Humidity - 6%
Medium Temperature-150F
Hot Water
Check
Lye
Percent Weight Remaining
Drying Time In Hours
100
90
80
70
60
50
40
30
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16


Graph III
Experiment 9
Influence Of Pretreatment
On Drying Time
Medium Humidity - 20%
High Temperature-180°F.
Hot Water
Check
Lye
Percent Weight Remaining
Drying Time In Hours
100
90
80
70
60
50
40
30
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

purpose of checking or cracking the surfaces. There are three methods in general practice: lye dipping, hot-water dipping and ordinary washing. Graphs I, II, III, IV, and V show the results on drying time of fruit treated the above ways and dried under several combinations of temperature and humidity.

At a temperature of 150° F. graphs I and II show an advantage in lye dipping. When a medium humidity is used the drying time is shortened by two to three hours over that required to dry prunes subjected to very little humidity.





With a high temperature and a low medium humidity (graphs III and IV), the check or untreated fruit dried as quickly as the lye. The hot-water dipping probably had no effect on the drying at the temperature stated. With the humidity high and the temperature high (graph V), the lye-treated fruit dried more quickly than either the hot-water dipped or the check.

Certain explanations may be given for these results. It may be that there is not the tendency toward moisture retention with the mechanical draft because under any and all conditions of temperature and humidity there is a limit to the diffusion rate. This would permit the untreated fruit to dry as quickly as the treated.

Until further work is done no definite conclusion can be made. There is little doubt, though, that in most cases the untreated fruit makes the best appearance, and packs with the least cracking or splitting after processing. This has been found true in commercial practice and is probably due to the method of dipping rather than the lye itself. When using lye, it is advisable to use solutions which are not too strong (not over 1½ percent), but keep them boiling hot. Prunes should not be kept any great length of time in this solution.

Traying. Many attempts have been made to find a metal tray that would not corrode or react with fruit and vegetable acids, and that would withstand the action of sulfur fumes. So far, even the most expensive alloys have not given entirely satisfactory results. The galvanized iron tray is in very general use in Oregon, and if it is kept clean and not used for sulfuring, it will dry a prune free from marks and with very little, if any, reaction from the metal.

In California the slat wooden tray is used and advocated. There is no reaction of the fruit with the wood but the circulation is not as good nor will the trays stand as rough handling.

For highest quality, it is essential that the trays be cleaned whenever the product sticks to the slats or wire.

Great care should be taken in the handling of the fruit on the trays. As the prunes come from the dipper, they should be placed on the trays in an uncrowded condition with the least amount of shaking. If the trays are stacked, sufficient space should be allowed between them to permit good ventilation. In placing and removing the tray, carelessness often results in scraping and mashing the fruit on the tray beneath. This not only damages the fruit so bruised, but causes excessive dripping, which spoils the appearance of the fruit placed below in the drier.

DRYING

Evaporators are of two general types; namely, (1) natural draft and (2) mechanical draft.

Of these two types there are numerous designs. During forty years or more there have been many ingenious devices placed on the market to aid drying. Actuating such a variety of constructions there have been the incentives of increasing capacity, of shortening the drying time, and of improving the quality. Too often the motive has been exploitation by certain individuals whose one and only objective was to make money in the commercialization of an idea without any effort toward sound principles of fruit evaporation and positive adaptability. The drierman contemplating building or remodeling his drier should investigate the advertised evaporator or dehydrator and make sure of its value before investing, or he will take chances not only with his money, but also with his good disposition in trying to dry his crop successfully. This does not mean that all patented dehydrators are not good, but rather that care should be taken in selecting one.

A discussion of the types of driers will not be taken up in this bulletin. Suffice it to say that whatever type is used, it should permit control of temperature, circulation, and humidity. It would be impossible even with control knowledge at hand to make use of it in the natural draft tunnel. The reason for this is obvious when it is realized that the temperature a fruit can stand is dependent to some extent on the circulation, and that the capacity of a tunnel per cubic foot is dependent, in some respects, upon the volume of air per minute, which will vary with circulation. In other words, nothing definite can be stated unless all factors, including circulation and humidity, are under the control of the operator. This is impossible with the natural-draft tunnel. So far, observation taken under actual working conditions through-

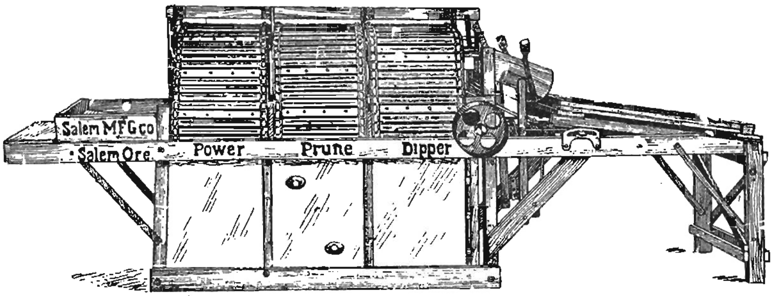


Fig. 4. Continuous Dipper and Trayer.
(Courtesy Salem Mfg. Co.)

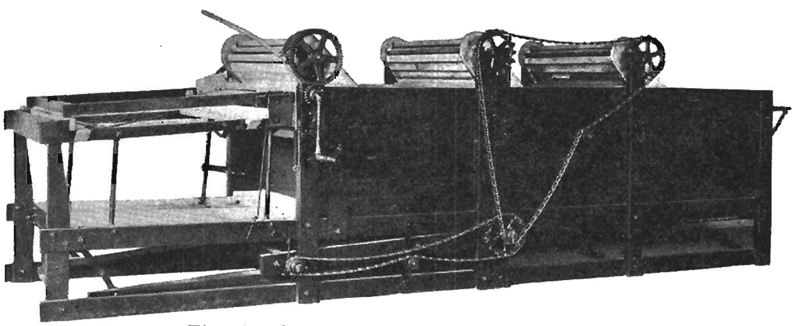


Fig. 5. Continuous Dipper and Trayer.
(Courtesy August Hilfiker.)

out a season's drying in seven or eight natural-draft tunnels has given no other conclusion than that it is impossible to control circulation and humidity and therefore the proper relation of the factors in drying. This would seem to indicate possibly, that there is nothing to do, nothing to watch or improve, in order to put out the best quality prune in the natural-draft tunnel. Such is not the case, however, for if proper attention is given the drier and the items of construction are followed, better circulation and better air distribution will result.

Accepting the tunnel drier as the best natural-draft tunnel in use, the construction and operation should follow an investigation of the conditions to be considered. In other words, preceding the selection of the best type of tunnel or drier there should be a study of the factors (temperature, humidity, and circulation) adapted to the principle of drying. In the building of an auditorium or a schoolhouse, the items of ventilation, light, sound, and convenient and economical arrangement are the actual guides. The same principle applies in the construction of a dehydrator.

Temperature. Heat is the first essential that comes to the mind when discussing the drying or evaporating of any product. There is no doubt that it is first in the cost column of production, both as an initial investment, and as a running expense.

Heat and quality of product are very closely associated. Quality may be lowered by heat in the following ways:

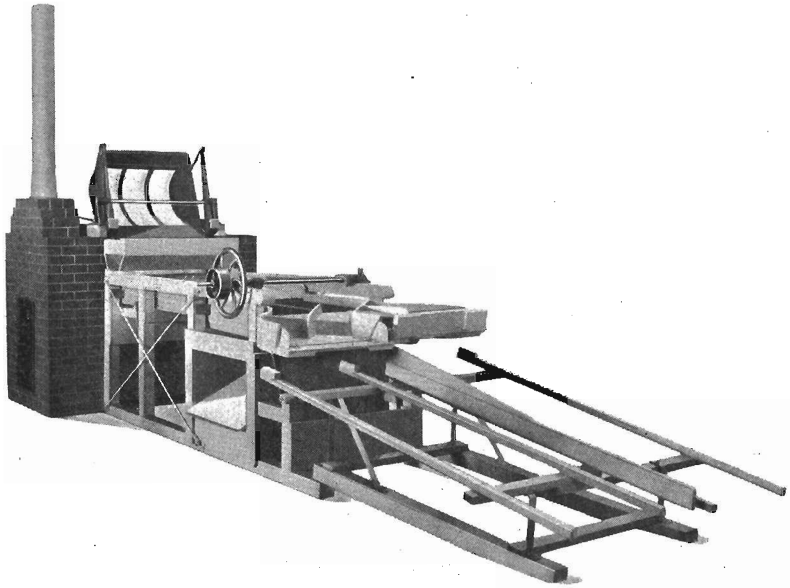


Fig. 6. Controlled Dipper, Grader and Trayer. (Courtesy Anderson Barngrover Mfg. Co.)

1. Too high initial temperature, which causes dripping.
2. Too high finishing temperature, which causes bloats, burns, and caramelization.
3. Too low temperature and a resulting long drying time in the tunnel, which may cause fermentation and often a moldy condition.

Humidity. Moisture is commonly considered as an enemy of drying. Moisture in the circulation lessens evaporation, but in the long run moisture in certain amounts will increase evaporation by permitting a steady, uniform conduction and diffusion. Under these conditions a better quality prune will be produced.

Moisture influences quality and economic production by (1) preventing case hardening, and (2) increasing the conductivity of the air.

Circulation. Air is the medium in which the heat and moisture act. The moving air is the conveyor of heat, and the conductivity of the heat is increased when moisture is present.

The velocity of circulation influences quality and economic production by controlling to some extent the rate at which evaporation takes place under any given set of conditions.

1. It may lessen chances of scorching (cooling effect).

2. It may decrease the drying time.

The interrelation of circulation, moisture, and temperature in their best combination, while not positively known, may be given in so far as experiment and practice have shown.

Evaporation is a common, every-day physical fact. It is recognized by everybody and is given no other thought than the accepted idea of a liquid disappearing into space. We almost instinctively associate wind, dampness or moisture in the air with drying. On a windy day, things dry very rapidly; while on a hot, sultry, or damp day, there is a retarding of the process, and we say it is close and uncomfortable. In certain

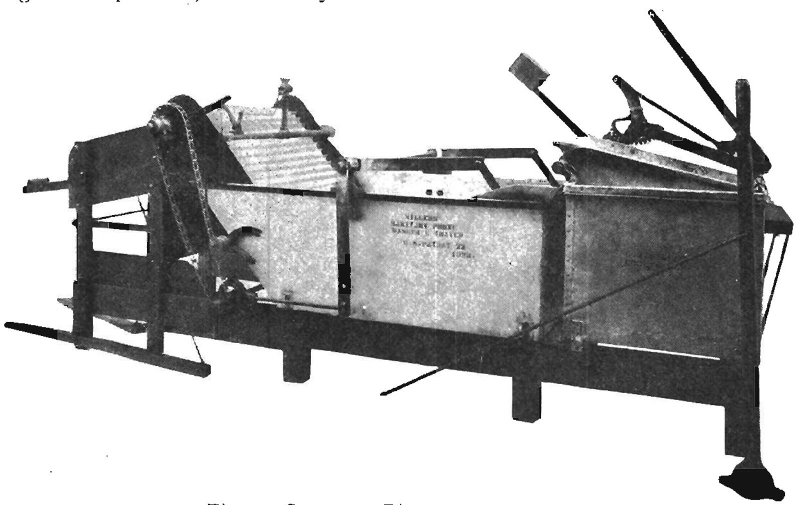


Fig. 7. Controlled Dipper and Trayer.
(Courtesy L. N. Miller.)

sections of the country, a very high degree of temperature can be tolerated with little suffering, while a much lower degree of temperature in other places causes prostration and death. Damp heat and damp cold are very noticeable, not because of more heat or cold, but because the water vapor in the air makes the air medium a better conductor.

If we put these common, every-day hints together, we can say that:

Increasing temperature increases evaporation.

Increasing humidity, applied under certain conditions, decreases evaporation.

Increasing circlation increases evaporation.

These facts are like almost all others, in that they have bounds and limiting factors and are subject to the law of application, namely: 1. Evaporation is subject to and dependent upon the medium from which it takes place, such as water, soil, fruit, lumber, etc. 2. The ratio or volume of the product to be dried to the drying power of the factors must be known. 3. There is a limit to the economical diffusion rate of each fruit or vegetable. Whether there shall be constant or changing conditions such as a higher or lower temperature at the beginning or end, and to what extent, if any, humidity accelerates evaporation from fruits instead of decreasing it, depend upon the product being evaporated.

The first and second limitations set are simply those of an overload of fruit to space and physical limit of speed of evaporation.

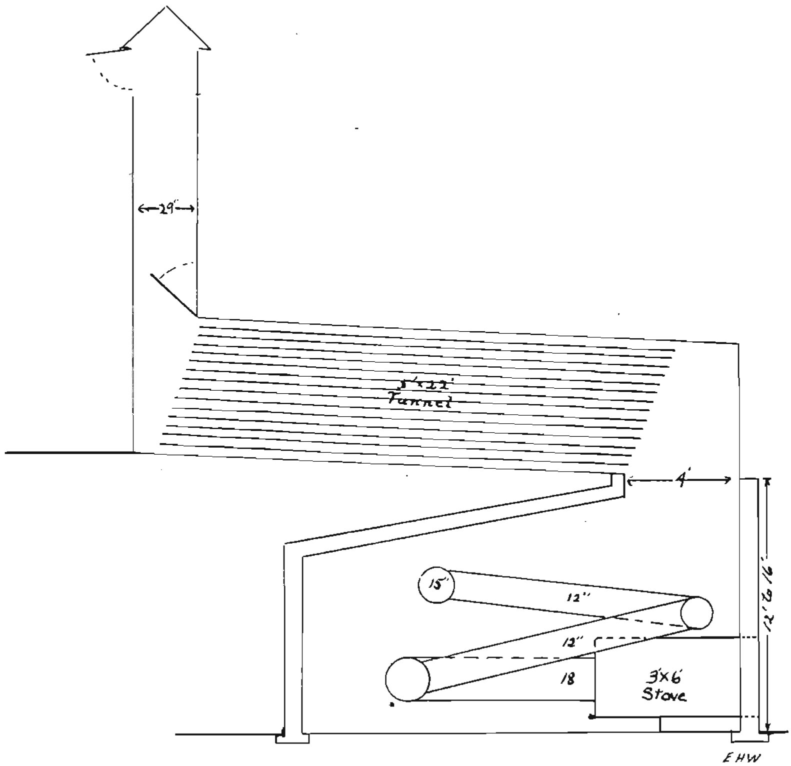
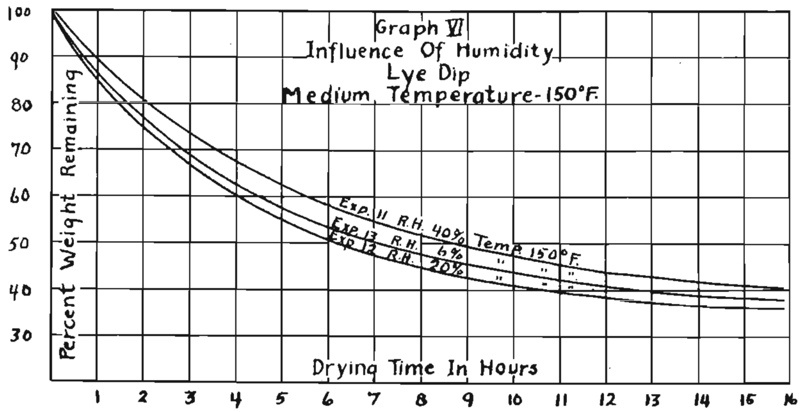


Fig. 8. Oregon tunnel drier.

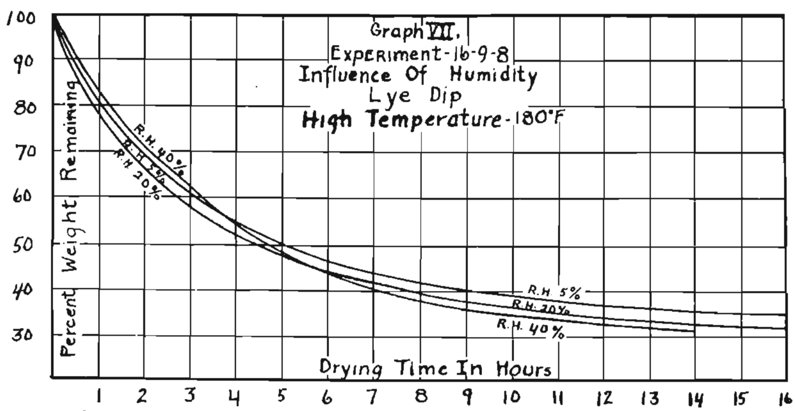
To illustrate: Temperature, humidity, and circulation are working in combination in removing the moisture from the fruit, but depending upon the fruit being evaporated, their power is limited even though their capacity is relatively unlimited. It is desirable that the evaporation be completed in the shortest time consistent with the best quality. Toward this end the following work has been done with as yet incomplete results.

It is seen that the problem of combining three variants is quite complicated. The range of temperature is from 100° F. to 200° F., circulation from 200 lineal feet per minute to 1200 lineal feet per minute, and humidity from the natural to 40 percent.

Lye dipped. A very small number of experiments were run since the time and equipment did not permit as thorough a test as should be given. The air movement was not varied and the humidity and temperature were varied to the extent of a medium low and high condition. Nine representative runs were selected upon which to base these results although more runs were made.



Graph VI. Showing the influence of humidity at a medium temperature.*



Graph VII. Showing the influence of humidity at a high temperature.*

Each run was made under controlled conditions. Both humidity and temperature were automatically regulated, and the speed of the fan was kept constant at 1200 lineal feet per minute throughout the run.

Experiments run at a temperature below 140° F. are not practical. Temperature is no doubt the most essential factor in drying. At the beginning of the experimental work moisture was considered important. Results seem to indicate, however, that humidity has to be carefully regulated to local conditions of dryer and fruit. Along with the experi-

*On the graphs the vertical axis represents percent loss of weight and horizontal axis the time in hours.

mental work conducted at the College there has been extensive opportunity for two seasons' observation under actual commercial condition; these show a benefit derived from humidity. It is not exactly easy to place the importance of humidity and circulation since both have been added factors in the mechanical draft dryer with only a limited trial. A circulation of 1200 lineal feet a minute has a tendency to lessen the influence of humidity. In other words, within a certain range the excess of one factor will tend to assume the work of the other. Case hardening is commonly recognized as the drying out of the surface of the prune before the inner moisture has been removed. This is due to the breaking of capillary movement by too rapid evaporation or by actual baking of the prune. There seems to be little doubt but that humidity for the purpose of maintaining capillarity in most fruits does not have to exceed ten to twenty percent. Under varying conditions of temperature, circulation, condition of fruit, and length of dryer, it has been observed to be essential to the amount of 20 to 25 percent.

1. Graph VI at a temperature of 150° F. shows a decided advantage in a medium relative humidity.

2. As the curve shows, a high humidity gives an even drying but greatly retards the drying rate.

3. With low humidity there is a rapid drying at first but a definite slowing of the process at the finish, which is suggestive of the need of increased moisture at the end of the drying period.

4. With a high temperature, the same general fact holds true, but as the temperature increases (graph VII), the moisture requirement must increase proportionately or the drying is greatly retarded.

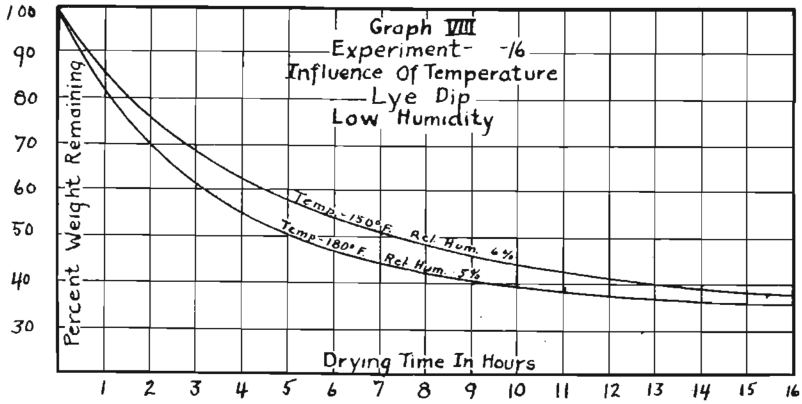
INFLUENCE OF TEMPERATURE

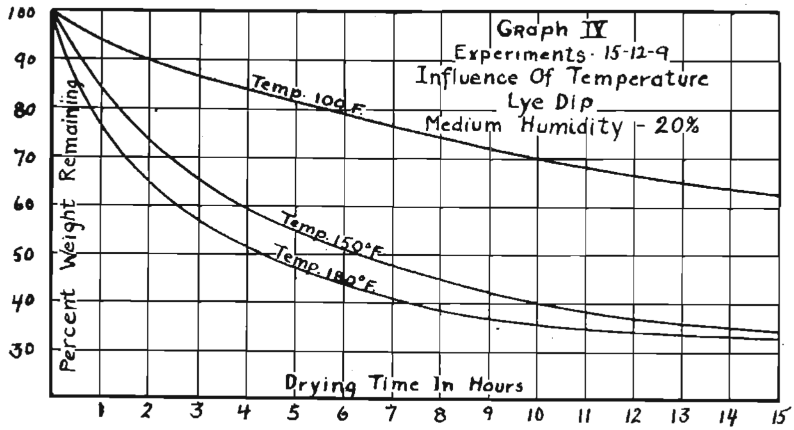
	Circulation	Humidity	Temperature
		%	
Low humidity	1200 L.F.M.	5	100° F.
	1200 L.F.M.	6	150° F. Graph VIII
	1200 L.F.M.	5	180° F.
Medium humidity	1200 L.F.M.	20	100° F.
	1200 L.F.M.	20	150° F. Graph IX
	1200 L.F.M.	20	180° F.
High humidity	1200 L.F.M.	40	100° F.
	1200 L.F.M.	40	150° F. Graph X
	1200 L.F.M.	40	180° F.

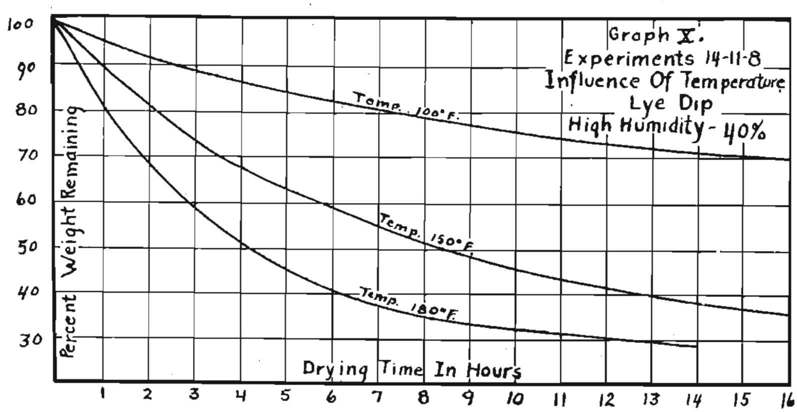
One group of tabulations illustrating conditions under which experiments were conducted, shows:

(1) Low temperatures of around 100° F. cannot be of practical use no matter what the humidity or circulation. In graphs IX and X a medium and a high humidity with a high circulation show the drying time to be well over fifty hours.

(2) Temperature has a decided influence on the drying time under all conditions at a low, medium, or high humidity. (Graphs VIII, IX, and X.)


Graph VIII
Experiment- -16
Influence Of Temperature
Lye Dip
Low Humidity
Temp.-150°F. Rel. Hum. 6%
Temp.-180°F. Rel. Hum. 5%
Percent Weight Remaining
Drying Time In Hours
100
90
80
70
60
50
40
30
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16


Graph IX
Experiments 15-12-9
Influence Of Temperature
Lye Dip
Medium Humidity - 20%
Temp. 100 F.
Temp. 150°F.
Temp. 180°F.
Percent Weight Remaining
Drying Time In Hours
100
90
80
70
60
50
40
30
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15


Graph X.
Experiments 14-11-8
Influence Of Temperature
Lye Dip
High Humidity - 40%
Temp. 100°F.
Temp. 150°F.
Temp. 180°F.
Percent Weight Remaining
Drying Time In Hours
100
90
80
70
60
50
40
30
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

Putting these results together and with other work that has been done, an approximation can be made of the best combination of factors, after we know the product to be dehydrated.

The questions to be answered for the specific product are: What temperature, humidity, and circulation shall be used?

In the case of prunes an entrance temperature of 120° to 130° F., gradually increasing to a finishing temperature not exceeding 150° to 165° F. seems most desirable.

A relative humidity between 15 and 30 percent with circulation from 600 to 750 lineal feet per minute appears to give good economic results.

These factors are suggested from the preceding work but not without a complete consideration of quality, which is given its equal in importance. It is to safeguard quality that, in spite of these good drying times, the higher temperatures with low humidity are not advised.

Natural-draft Oregon tunnel drier. In the plans submitted it should be understood that there are points of major importance and that there are minor considerations which can be altered best to suit the building site and personal preference. It is always necessary to have in mind the most economical construction consistent with the desired points. Consequently the specifications should be interpreted with an adaptational point of view and a discriminating mind.

The following should be recognized and unquestionably insisted upon in all plans:

1. Depth of furnace chamber 12′ to 16.′
2. Sufficient and properly distributed air intakes into furnace chamber.
3. Sufficient radiating pipe properly placed in furnace chamber, using 36″ x 6′ furnace and 15″ pipe.
4. Air intake slightly in excess to area between trays. (Throat of tunnel.)
5. Slope of tunnel, 1″ to 3″ to the foot.
6. Distance of runs apart 4″ to 4½″ center to center.
7. Stack about 10′ to 15′ high with a ventilator subject to regulation.
8. Length of tunnel from 22′ to 26.′
9. Equipment for washing.

Three to four tunnels to a furnace chamber are found to be satisfactory. The specifications included herein show three tunnels to each stove, the smallest unit possible of construction within economical limits. When thirty or forty tunnels are included in one building it is necessary to have at least one or two runways for trucking and passing back and forth.

The plans show dimensions and all points of construction, and while the above points are important, they are not indicative of constant controlled drying conditions. They will give and permit of the best means of temperature and circulation control, but the best is far from perfect. When the weather changes, drying conditions will change and the periodic spells that are so annoying to the manager of a drier will still be present to test his patience.

The list of materials and labor are submitted below. Labor will vary as will the material, according to local conditions; consequently, no cost is given, although it has been found that $450 to $600 per tunnel will cover entire cost for constructing drier.

Sufficient floor space should be provided for at both ends of the tunnel—at least fifteen to twenty feet. This will allow for trays, trucking, stacking of fresh fruit, dipping and washing machinery, and the sorting and sacking of dried product.

Large, full-sized blue-prints will be sent to any person desiring to construct a unit of tunnels. The following sketch will give the essential features and parts of the drier.

SAMPLE BILL OF MATERIALS—THREE-TUNNEL DRIER.

A. Furnace chamber:

1: 3′ x 5½′ hop stove with 6½ feet of 18″ pipe to header
1: 18″ header, 8′ 3″ long
1: 12″ header 7′ long
2: 12″ elbows
22 feet 15″ pipe for outlet to stack
61 feet 12″ pipe plus 8 inches for each joining
124 building tile

B. Tunnel:

19 feet 4″ x 4″ material
11: 8″ x 12′
6758: 2″ x 4″ material
1848 running feet 1¼″ x 1¼″
6311 feet ⅜″ x 3″ flooring No. 1 grade
8: 2″ x 12″ x 12′
540 shingles laid 4 inches to the weather
85 feet small cord rope
3 single pulleys, 3 double pulleys
6: 3″ single strap hinges
18: 5″ double strap hinges
6 bolt latches
6: 4″ double strap hinges
1: 15″ steel smoke stack, 39′ high
336 trays 31″ x 37½″ x 1⅝″ (Allowing ⅓ extra)
Roof of furnace chamber may be reinforced with 12 lb. 1½″ round rods 11′ 2″ long—134 feet in all. By using triangle mesh concrete reinforcement (No 168), this could be easily used in either the 24″ or 48″ width. 134 square feet will be necessary.
32.7 cubic yards of concrete for walls and top mixed 1-2-4. Top to be reinforced as previously stated.
44 sacks cement
13.5 cubic yards of sand
26.5 cubic yards of gravel
3.7 cubic yards of concrete for base 11′ 2″ x 15′ 5″
If the ground is soft, base will have to be larger, 1-3-5.
4 sacks cement
2 cubic yards of sand
3 cubic yards of gravel
Total 48 sacks Portland cement
15.5 cubic yards of sand
29.5 cubic yards of gravel

Mechanical-draft tunnel. There is nothing exceptionally complicated or technical about a mechanical-draft tunnel. In the past the expense of construction and equipment was uppermost in the mind, with the result that the use of the dryer has been given only a passing consideration.

Work has been done at this Station with the object of simplicity of construction and economy of operation. Considering the thousands of tunnel driers already built, it was reasonable that an attempt should be made to install the mechanical draft and humidity control in these structures. The results were very satisfactory, as can be readily seen by the figures presented.

Reconstruction Oregon tunnel drier. The Oregon tunnel drier constructed at the Oregon Agricultural College Experiment Station has been altered by the addition of a recirculating system to meet the needs of a more constant temperature; to increase the relative humidity and to maintain a more constant circulation. As a result of these factors a more uniform product is obtained.

The air was taken from the drier through the floor at the filling end and forced into the enclosed furnace chamber. It was baffled to circulate between the hot pipes and was forced up through the throat of the drying tunnels at a velocity of approximately 1,000 lineal feet a minute. The fact that only a small amount of air was taken in through an opening 2" x 10" and only a small amount allowed to escape through a similar opening in the stack, tended to increase the humidity from 18 to 23 percent, which remained fairly constant throughout the drying period. The increased humidity was beneficial in keeping the fruit pliable and in preventing case hardening.

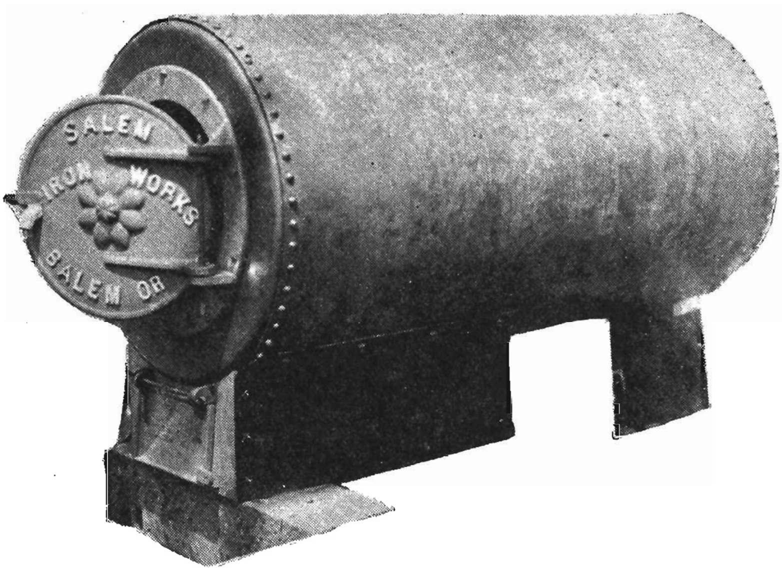


Fig. 9. Type of stove for recirculation or natural-draft drier. (Courtesy Salem Iron Works.)

The consumption of fuel was also reduced to a minimum by recirculation of the air, as only 10° to 20° of heat were lost in passing the heated air through the tunnels. It cost $2.40 for electric power and required one-third of a cord of wood at $6.00 a cord to dry one ton (dry weight) of prunes. The illustration (Fig. 10), indicates the manner in which the air was handled in recirculating. A No. 8 Multivane fan driven by a 7½ horse-power motor was used. A maximum of approximately 750 lineal feet of air a minute was maintained between the trays at all times, and prunes were dried in 18 to 24 hours.

Too much emphasis cannot be placed upon the fan which is to circulate the air. A fan of improper construction and inadequate capacity will cause much grief and will not do the work intended. If it is decided to install a fan for handling the air in recirculation the matter should be referred to the Station before steps are taken to install such equipment. In this way the proper installation can be had at a minimum cost. In the past, fans have been tried and have failed because the operators installed fans of inadequate capacity and of wrong design.

The total cost of equipping the 3- or 4-tunnel Oregon drier with recirculation need not exceed $700, exclusive of power. One fan of sufficient size will be ample to handle recirculation in four tunnels.

Where fans are installed in short tunnels there is a tendency to have a greater dripping. This is due to the fact that the prunes are placed in a tunnel where the temperature is quite high, which causes rapid expan-

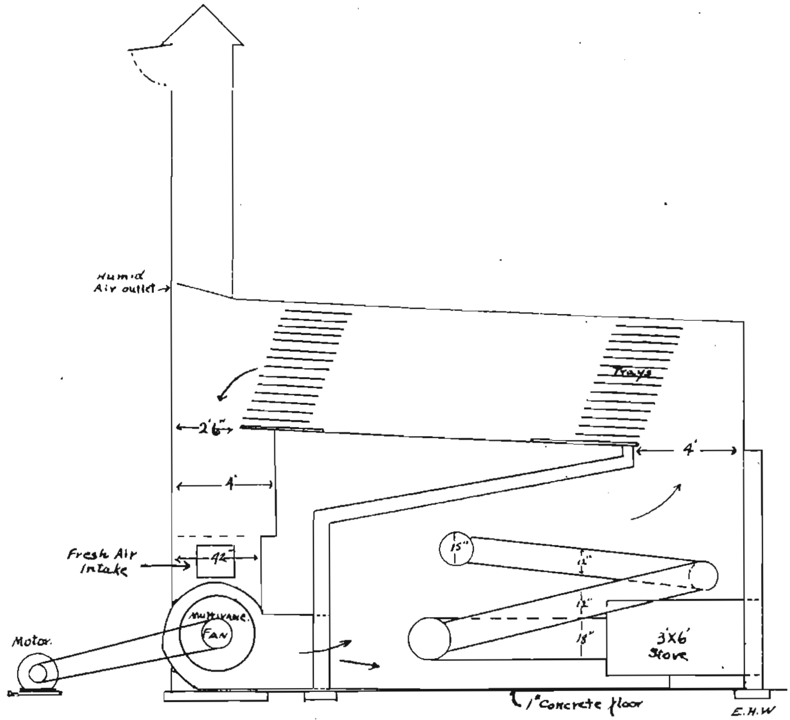


Fig. 10. Reconstructed Oregon tunnel.

sion of the juices and consequent dripping. This can be decreased by increasing the length of the tunnels so that the temperature drop from the throat to the outlet end is greater. Roughly it can be figured that there will be about three-fourths of a degree of heat lost every lineal foot the air travels while passing over the prunes.

PROCESSING AND PACKING

This last operation before marketing the product is very essential. When it is realized that a medium quality product can often be sold for an extravagant price because of its appearance, there is ample reason for emphasis on the processing and packing of prunes. Appearance is the first and most lasting impression to the public provided the quality is within reason. It indicates cleanliness and care, and stimulates an appetite on the part of the purchasing public.

Various methods are used in processing the prune. In the first place, no prune can be properly processed if it is not properly sorted and sized. You cannot process mashed, rotten, burned, or otherwise poor fruit and expect your good reputation to be maintained. It will appear to improve the poorest but will never make or approximate a good quality product.

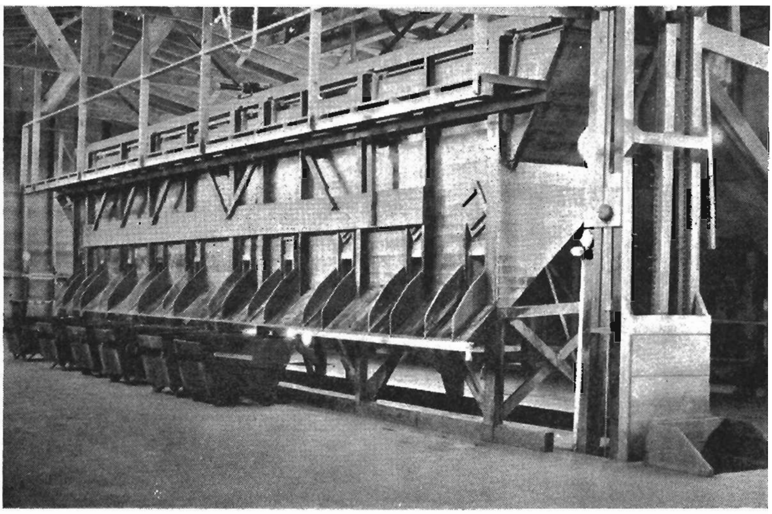


Fig. 11. Dried-prune Grader.

Grading or sizing precedes processing and packing. With prunes this is a very particular point. Sizing is done with screens over which the prunes are shaken—ten or more sizes being recognized. Fig. 11 represents the general type of graders. It is a large, bulky machine situated usually on the second or third floor, from which the prunes are turned into bins and from the bins into the processing machinery and packed. Prunes are packed according to size, the number of prunes in a pound designating the size, such as 20-30's, 30-40's, etc. In making the packed sizes the nine point system is used. This involves the taking of two sizes—say 30's and 40's and mixing them so that the 30's-40's will run close to 39 a pound. Care must be taken to have moisture uniform and constant, otherwise a loss of a percent or two might cause the placing of a pack in the next size with the resulting reduction in market value.

There are various means of processing, but in general there are two methods, involving the use of hot water or steam. The latter seems to be the best method as it is less cumbersome and sterilizes with the least amount of sugar loss. Hot water softens the prunes and causes more

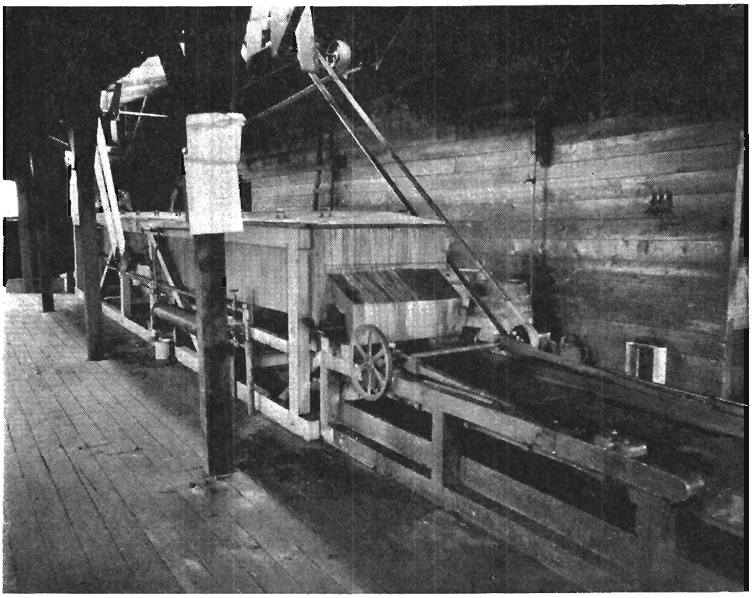


Fig. 12. Shaker type of prune processor.

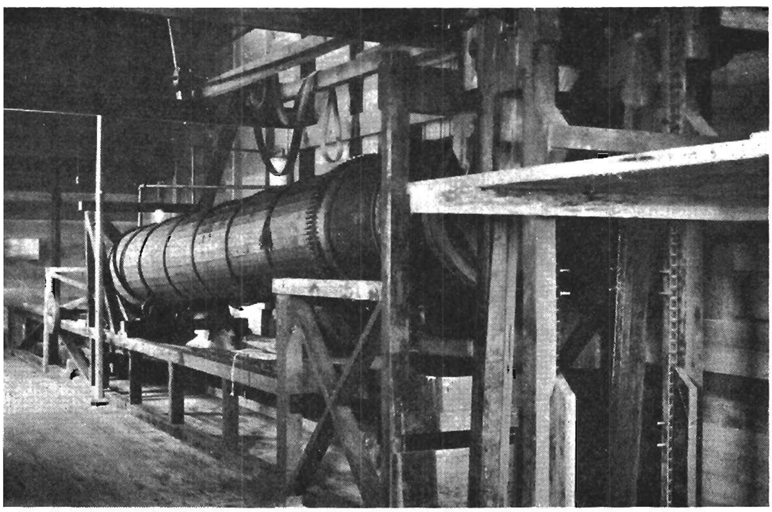


Fig. 13. Drum type of prune processor.

trouble in operating, as it is harder to avoid mushing and gumming the fruit.

Fig. 12 illustrates the general shaker type. Fig. 13 is the drum type, which is not as satisfactory, as it tends to make the fruit sticky and more ragged as the steam condenses, soaking and mushing the fruit.

As the fruit passes through the shaker type of processor (Fig. 12), which is nothing more than a box open at both ends, it receives a spray of warm water at the start, then a minute or so of live steam at a high temperature, finally emerging heated to the pit. Sometimes, at the last, a hot-water spray is given and then a final blast of dry steam.

Packing is done immediately. The fruit being hot dries quickly, and while it is warm and a little damp when put in boxes, it does not necessarily gain or lose much weight. The fruit will gain in weight from nothing to four or five percent, according to the condition it is in, and the method of processing used.

In Fig. 14 can be seen the packing equipment. Ninety percent or more of the prunes are packed in 25-pound boxes. From a hopper above, the prunes are dropped into a paper-lined, 25-pound box, conveyed to the press, and from there to the nailer, ready to be labeled and sold.

THE MARKET

Prunes may be sold in advance of the crop, but usually only a portion of the crop is sold in this way. This is true both with the grower and the packer. The contracting of fruit is very common; while no figures are at hand, it is possibly safe to say that most of the growers contract for the greater part of their fruit.

The price quoted to the grower by the packer is an agreed price set by the various concerns or a price set by a single concern. It is evident that a large margin is necessary because of the gamble taken by the buyer on the quality and condition of the fruit. Quality in fresh or dried fruit will demand its price or pave a way for its own marketing.

The packer when quoting his price to the brokers and commission men who handle his pack gives a figure below the actual selling price. This is a bulk basis figure and to it is added a regular differential. The following figures represent the system used and the actual opening prices of the Oregon Growers' Cooperative Association for 1921.

MISTLAND CROP

a.	30-40	40-50	50-60	60-70	70-80	80-90	90-100	100-120	120 and over
b. c.	8½ 3¾	7½ 3¼	6 2¾	5½ 2¼	5 1¾	5 1¼	5 ¾	5 ¼	Bulk basis; add regular differential
d. e.	12¼ 1½	10¾ 1½	8¾ 1½	7¾ 1½	6¾ 1½	6¼ 1½	5¾ 1½	5¼ 1½	Price packed in 25-pound boxes less boxing cost
f.	10¾	9¼	7¼	6¼	5¼	4¾	4¼	3¾	Actual selling price less boxing

Note that the bulk basis price quoted was 8½, 7½, etc., while the actual selling price per pound was 10¾, 9¼, etc.

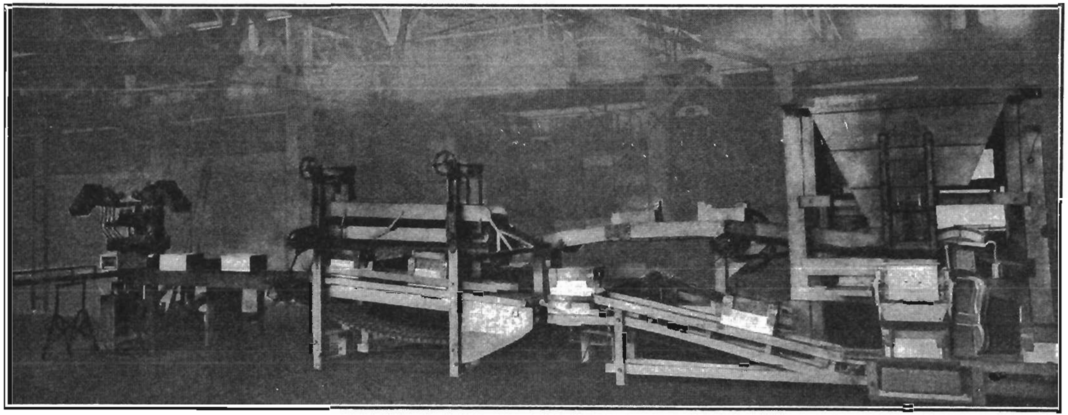


Fig. 14. Prune packing equipment. (Courtesy Anderson-Barngrover Mfg. Co.)

The figures on line c represent the differential plus the boxing cost, which gives in line d the actual selling costs to the broker in 25-pound boxes. Therefore, in order to get the actual selling price on a bulk basis, the boxing cost (one and a half cents) is subtracted as per line e.

SUMMARY

1. A standard-quality product is of first importance in the future marketing of the Italian prune.

2. The quality must not be an afterthought but must be kept constantly in mind from the growing and harvesting through the packing of the fruit.

3. Although it seems but a small matter, sanitation is essential, and is a big matter from the standpoint of quality.

4. Smaller boxes should be used in the field as large boxes mash the fruit.

5. Lye-dipping of the fruit is not essential, although it increases the drying rate. When using lye, however, the fruit should be thoroughly washed before drying.

6. The Oregon tunnel can be made into a mechanical draft tunnel with controlled temperature, circulation, and humidity.

7. The type of drier is not as essential as a knowledge of the proper relation of the drying factors to obtain *quality*. The proper temperature, humidity, and circulation for the Italian prune have been approximated by experimental work at the Experiment Station. Temperature 150° to 165° F. Circulation 600-750 lineal feet per minute. Humidity 15 to 30 percent.

8. Processing and packing the prune will not remedy mashed, moldy, or dirty fruit.

9. Understand the handling and marketing of the prune. It will make you, as a grower, more capable of intelligently handling your crop.

ACKNOWLEDGMENTS

Sincere appreciation is expressed to the people and firms who have rendered assistance in making this bulletin complete.