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EFFECT OF ACID WASH ON THE KEEPING QUALITIES OF APPLES

A Practical Home-made Apple-washing Machine

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EFFECT OF THE ACID WASH ON THE KEEPING QUALITIES OF APPLES

During the early part of the 1927 shipping season, shippers reported losses due to excessive decay in lots of apples washed in the hydrochloric-acid solution, the general opinion being that the acid was the direct cause of this decay and not the blue-mold organism. Owing to these reports it was considered desirable to conduct a series of storage tests with some of the more important commercial varieties, treated and untreated, to determine the cause of these troubles.

Scope of Work.—Inasmuch as considerable work has been carried on by other investigators to determine the efficiency of hydrochloric-acid solutions for the removal of spray residue, it was not deemed desirable to consider this phase, except to make a comparison between the efficiency of the soda-ash solution and the acid-wash*. The main work was centered on storage tests with treated and untreated apples to determine the effect of washing on the fruit itself, methods of preventing injury, the use of disinfectants to prevent decay, and testing the efficiency of a home-made washing machine suitable for the use of the small grower.

Experimental Data

Methods and Materials.—The fruit used in the storage tests was first divided into lots as follows:

Lot 1.—Untreated.

Lot 2.—Washed in acid solution 0.33 percent or 1 gallon hydrochloric acid to 100 gallons water.

Lot 3.—Washed in acid solution—2 gallons hydrochloric acid to 100 gallons water.

Lot 4.—Washed in soda-ash solution—32 pounds common salt and 32 pounds sal soda to 100 gallons water. Not heated.

Lot 5.—Same as lot 2 with the addition of 2 quarts formalin to the 100 gallons of acid solution.

Lot 6.—Same as lot 3 with the addition of formalin as in lot 5.

The time of exposure of the fruit varied from 30 to 45 seconds, depending on how evenly the fruit was fed into the machine. The fruit was run from the washing machine into picking boxes and each lot was then divided in half, one-half of the fruit being dried by running thru a Moe wiper, the other half being sorted and packed immediately and with as much moisture as would remain on the apples in the washing process. All fruit was sorted to conform to a

*(Colo. Agr. Exp. Sta. Press Bul. No. 63.)

three-grade combination face-and-fill pack. The fruit was not wrapped and the package used was the standard bushel apple box with the regular paper liners. In the case of the untreated lots, the fruit packed dry was sorted and packed directly from the picking boxes; that packed wet was first sprayed with water from a hose and then sorted and packed. All apples in the dry pack, except the untreated, were sorted and sized over a Cutler grader. The untreated apples received much less handling and should on this account keep better in storage. Each lot, with one or two exceptions, included five varieties; Jonathan, Rome Beauty, Winesap, Arkansas (Mammoth Black Twig) and Ben Davis.

As soon as the apples were packed they were placed in both common and cold storage, each storage containing half of each lot of all varieties, both dry and wet packed. The storage period for the Jonathans extended from November 15 to January 20; for the other varieties from November 15 to March 20.

At the end of the storage period all boxes were opened and the apples counted. The percentage of decayed and other defective apples was ascertained, the fruit resorted and repacked and held in common storage for sale. On June 1 there remained about 30 boxes yet in storage most of which, both washed and unwashed, were unsaleable at that time. However, these apples were still in good condition on May 1 after which the temperature in the storage rose above 60 degrees F. During the regular storage period temperatures in the common storage ranged from 30 to 40 deegrees F; in the cold storage the temperature did not vary from 32 degrees F.

The washing and packing of the fruit was carried out on a commercial scale using the regular equipment in the college farm packing plant at Austin after the farm crop had been packed. No attempt was made to handle the apples with any more care than they would have received under average conditions so that results would be comparable with those from the poorest pack as regards rough handling. However, one lot each of carefully handled Jonathan and Rome Beauty apples was included as a check on the influence of rough handling.

The washing equipment consisted of a home-made machine of the Oregon paddle-wheel type, similar to the one described in Fig. 4. A Moe wiper with the first two rag rolls replaced by bristle brush rolls was used for the drying.

Source and Condition of Fruit.—The Jonathan apples were obtained from the Corey-Austin section and from one orchard; all of the other varieties from the Paonia section and from one orchard. In this manner the results were not affected by cultural or climatic conditions. The Jonathan apples were in very poor condi-

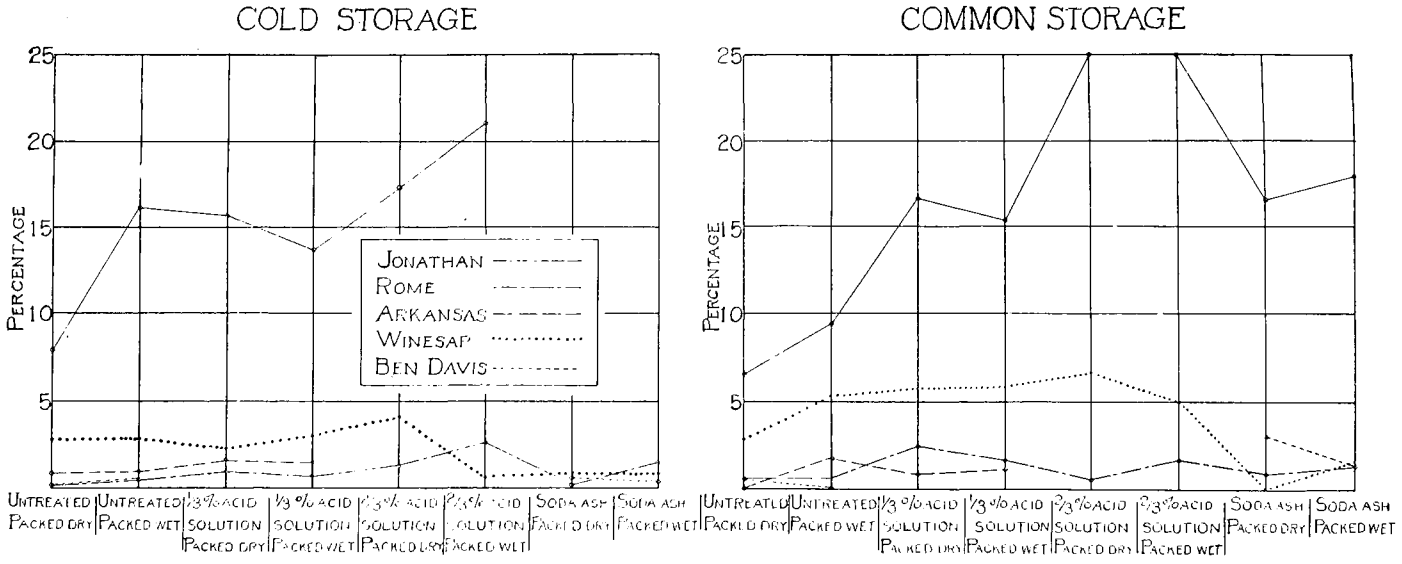


Fig. 1.—Percentage decay appearing in all lots and varieties in both common and cold storage. Little or no decay appearing in any lots previous to January 1.

tion, not very firm and showing a high percentage of decayed apples. On this account they were sorted before being put thru the washer, the number of decayed apples amounting to 25 percent. In spite of this sorting some decayed apples went thru the washer, thereby infecting the acid solution with spores of the decay organism. The fruit had been harvested late, in an over-ripe condition, and held under an open shed for two weeks or more before hauling to the packing plant. It had also been roughly handled and contained a high percentage of stem-punctured and bruised apples. All fruit of the other varieties was sound and in good condition, with little or no decay apparent, but with some broken skin and stem punctures present.

Influence of Acid Solution on Decay.—In Tables 1 and 2 is tabulated the percentage of decay in each lot in both common and cold storage. Reading each line from left to right it can be seen that only with the Jonathan variety was there any consistent increase in decay in the treated lots over those not treated. All other varieties showed approximately the same amount of decay in both treated and untreated lots. In a few cases the untreated lots show more decay than the corresponding treated lots. This would indicate that the acid wash itself has no effect on the amount of decay. That the apparent increase in decay with the Jonathan variety does not indicate that this variety alone is more susceptible to injury will be shown later. Increasing the strength of acid, within limits, did not increase decay. However, 2 gallons of 0.33 1-3 percent hydrochloric acid was the strongest solution found necessary to remove the residue and was the strongest wash used in these tests. The results obtained are more clearly indicated in Figure 1.

TABLE 1.—Effect of washing on decay. Cold Storage. Percentage decay.

Variety	Untreated		Acid wash .33%		Acid wash .66%		Soda wash	
	dry	wet	dry	wet	dry	wet	dry	wet
Jonathan (a)	.... ..	.... ..	.... ..	.... ..	3.31	.... ..	.... ..	.... ..
Jonathan	8.0	16.4	15.6	13.0	17.30	21.0	.... ..	.... ..
Rome Beauty	0.0	0.3	0.7	0.5	1.1	2.4	0.0	1.1
Arkansas	0.8	0.9	1.7	1.5	.... ..	.... ..	.... ..	.... ..
Winesap	2.8	2.8	2.3	3.0	4.1	0.3	0.8	0.6
Ben Davis	0.0	0.6	.... ..	.... ..	.... ..	.... ..	0.4	0.3

(a)—This lot consisted of apples carefully handled and fully dried before packing. Fruit was sound with no decay when packed.

TABLE 2.—Effect of washing on decay. Common storage. Percentage decay.

Variety	Untreated		Acid wash .33%		Acid wash .66%		Soda wash	
	dry	wet	dry	wet	dry	wet	dry	wet
Jonathan (a)	....	....	....	....	4.2	....	....	....
Jonathan	6.5	9.5	16.8	15.3	25.0	25.0	16.5	18.8
Rome Beauty	0.3	0.3	2.1	1.4	0.5	1.6	0.9	1.1
Arkansas	0.0	2.0	0.7	1.2	....	....	....	....
Winesap	2.9	5.1	5.7	5.9	6.7	5.0	0.0	0.3
Ben Davis	3.0	0.0	....	....	....	....	3.0	1.4

(a)—This lot consisted of apples carefully handled and fully dried before packing. Fruit was sound with no decay present before packing.

The data given in these tables also indicate that the soda-ash solution used cold did not in itself cause decay. The decay tabulated here was due almost entirely to the blue-mold organism. A few of the apples showed decayed spots apparently due to black rot and some calyx discoloration due probably to arsenical injury occurring on the tree as both of these could be found on apples not yet harvested.

Influence of Packing Wet on Decay.—With the exception of the Jonathan variety no general increase of decay occurred where the fruit was packed wet, there being little or no difference in the percentages, in some cases the wet showing less than the dry packed. However, this fruit was held in a ventilated storage for a short time and the same results might not be obtained were they placed in a warm car with the vents closed as occurred in many cases during the past season. This appeared to be closely connected with storage temperatures.

Influence of Storage on Keeping Quality.—So far as decay was concerned there was little difference between the common and cold-storage lots as to the amount present, except in the case of those washed in soda-ash solution. What difference occurred was in favor of the cold storage. This however, is to be expected under average conditions. In this case the common storage used was above the average and during the storage period the temperature did not range above 40°F. at any time. Later when temperatures rose above 40 degrees the amount of decay increased more rapidly in the common-storage lots than those in cold storage. Shriveling did not occur in the cold-storage lots while those in common storage showed a rather high percentage of apples so affected. (Table 3.) The kind of treatment had no connection with the trouble, there being no difference in the amount present between the treated and untreated lots. The Winesap and Jonathan varieties showed the highest percentages due apparently to insufficient atmospheric moisture in the storage for these particular varieties. The Jonathan apples showed more Jonathan spot and the Rome Beauty and Arkansas more scald in the common than in the cold storage. Washing did not influence the

TABLE 3.—Influence of Storage on Shriveling.

Variety	Cold Storage		Common Storage	
	Untreated %	Treated %	Untreated %	Treated %
Jonathan (a)	.... ..	0.0	.... ..	4.6
Jonathan	0.0	0.0	9.7	9.5
Rome Beauty	0.0	0.0	0.6	0.5
Arkansas	0.0	0.0	0.0	0.0
Winesap	0.0	0.0	0.3	1.0
Ben Davis	0.0	0.0	0.0	0.0

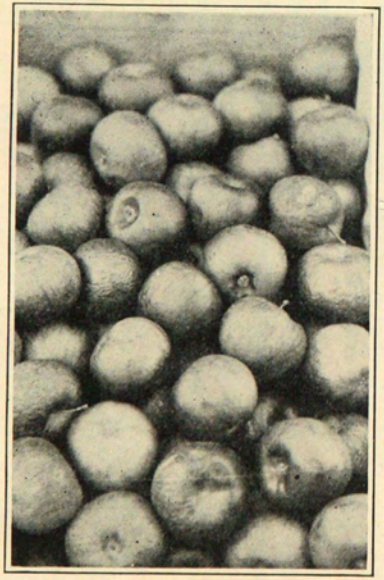
(a)—This lot consisted of apples carefully handled and fully dried before packing. Fruit was sound and free from decay when processed.

amount of Jonathan spot, scald, internal breakdown and shriveling.

Influence of Washing on Firmness of the Fruit.—There was no apparent difference between the treated and untreated lots as to firmness, general appearance or taste. In no case was there any acid injury apparent in any of the fruit at the end of the storage period. All decay present had entered thru stem punctures or broken skin such as occurred thru bruising and where the stems had been pulled out in harvesting. No soft decay was found in the calyx ends. Later on, about the end of May, when temperatures in the storage reached 60 degrees F, some calyx discoloration appeared and increased with the rise in temperature. That this was not due to the acid used is indicated by Fig. 2. Both the treated and untreated apples showed this injury to about the same extent, possibly due to free arsenic accumulating at this point during the late fall rains previous to harvest. These photographs are not intended as a comparison between the keeping quality of treated and untreated apples as they were from different orchards and kept in different storages. This type of injury was also found on fruit while on the trees, and is probably more prevalent in wet seasons. This can also occur in the washing operation where an excess of free arsenic has accumulated from failure to change the acid solution frequently or from lack of thoro rinsing.

Influence of Disinfectants on Decay.—The use of such disinfectants as formaldehyde in the acid solution has not prevented or decreased the amount of decay (Table 4). In fact an attempt to use the same acid solution for the longer period with the formaldehyde actually resulted in an increase in the decay.

Efficiency of Solutions.—No difficulty was encountered in reducing the arsenical residue to below .01 grains of arsenious oxide to the pound of apples with 2 gallons of hydrochloric acid to the 100 gallons of water under commercial conditions and with the equipment used. However, none of the fruit was held long enough to produce a heavy coat of wax previous to washing. The soda-ash solution used cold was about 50 percent as efficient as the acid. However,



ACID-WASHED APPLES

UNWASHED APPLES

Fig. 2.—Photographed June 9, 1928. Both lots held in common storage and showing same type of decay in stem and calyx ends.

heating this solution would undoubtedly increase the efficiency. It is not considered practical for the average packing plant.

Dry wiping did not consistently reduce the arsenical residue to or below the higher tolerance allowed during the past season. Storage tests carried on in 1926-27 indicate that the keeping quality of the fruit is not affected where no bruising occurs in the process and is not infected with decay before running thru the machine. Apparently the smaller the amount of residue present, the less efficient is the dry wiper in removing same.

TABLE 4.—Influence of disinfectant on amount of decay.

Variety	Cold Storage		Common Storage	
	Acid solution only	Acid solution formaldehyde added	Acid solution only	Acid solution plus formaldehyde
Jonathan	17.0	20.8	25.0	21.9
Rome Beauty	0.0	1.7	2.1	2.0
Winesap	2.3	1.3	5.7	7.0
Ben Davis	0.4	5.2	3.0	9.6

Discussion

Like all other operations to which fruit is subjected during harvesting and packing, injury can occur during the washing process. Such injury can be avoided with no great difficulty or expense. In many cases the washing is blamed for injury which has occurred in the picking and handling previous to the washing. The act of washing apples in acid solution, at the strengths recommended, does not in itself cause injury. This statement is based on the results obtained with carefully controlled storage tests, observations on more than three thousand boxes of apples held in common storage for periods ranging from 20 to 60 days and reports on nine cars of apple shipped East. All the more important varieties were included in these observations.

Knowing the properties of hydrochloric acid, we would assume that any injury to the fruit from this source would appear as dead areas in the exposed flesh or on the skin surface (ending in decay), and general discoloration and excessive shriveling due to wax removal. Examination of the apples as noted above failed to show any general discoloration or breaking down which was not caused by blue mold or similar decay organisms.

In nearly all cases, decay was caused by the entrance of these organisms thru broken skin or bruises. Occasionally an apple would show a rather dark decay which from its color and general symptoms might be due to black rot, a disease which affects the fruit while on

the tree. In no case was the decay able to penetrate the unbroken skin even tho the apple were entirely covered with the spores of the blue mold. If this decay had been caused by the acid the untreated lots would have been entirely free from such troubles. That such is not the case is indicated by the results as given in Tables 1 and 2. An examination of over two-hundred boxes of commercially washed and packed apples, after 60 days in storage, failed to show more than six apples in the entire lot showing decay. Very few apples showed any discoloration at the stem or calyx end during the storage period. This same injury, however, was found on fruit recently picked and which had not been washed. Also, the untreated lots showed about the same amount of this injury as those treated. After May 1, when the storage temperature rose above 60 degrees, this type of injury increased. Indications are that this trouble is probably due to free arsenic accumulating at these points during the fall rains, to lack of frequent changing of the acid solution, or from failure to rinse thoroly.

Except in the case of the Jonathan variety, there was no general increase in the amount of decay in the treated lots over those not treated. The increase with this variety can be directly traced to the heavy contamination, state of maturity and rough handling of the fruit before washing. It will be noted that the check lot of washed and carefully handled apples contained less decay than those not washed.

There was no connection between the amount of shriveling and washing. Washed apples could not be distinguished from those not washed either by appearance, feel or taste. Internal breakdown was closely connected with size and maturity at time of harvesting rather than with the method of treatment, being more serious in the larger sizes and fruit that was over-ripe when picked.

The sal-soda solution used cold did not affect the keeping quality of the fruit.

Under the conditions existing in these tests, packing the fruit wet did not appear to cause an increase in the amount of decay. However, the apples were placed in a ventilated storage shortly after packing. Experience has shown that wet fruit cannot be safely loaded directly into warm refrigerator cars with the vents closed as happened in several cases during the past season. This resulted in considerable decay, particularly where poor sorting had permitted the packing of apples with small spots of decay.

The use of disinfectants in the acid solution failed to prevent or decrease the amount of decay. In fact an attempt to use the acid solution with the formaldehyde for longer periods actually resulted in increased decay due to contamination and the greater spread of

the spores over fruit not already so contaminated. This is one of the weak points of the washing process but can be avoided without any great difficulty.

Over-ripe fruit is difficult to clean and is subject to greater injury from stem punctures and bruising than apples just mature. Apples should be picked when ready and washed as soon as possible. Care should be taken to prevent rough handling.

It is commonly known that such varieties as Jonathan and Grimes Golden should be placed in storage, preferably cold, within a short time after picking to prevent excessive deterioration. This was not the case during the past season as, owing to lack of equipment, the apples were held for a considerable length of time in open sheds under relatively high temperatures and in many cases exposed to the sun. It is the writer's opinion that all shipments of Jonathan and Grimes Golden apples destined for long hauls should go under ice. This would apply to early fall shipments in particular.

The strength of acid used should be no greater than required to remove the residue from the fruit being washed. This will vary according to the amount of residue present, the temperature of the solution and the amount of wax on the fruit. Two gallons of commercial hydrochloric acid to 100 gallons of water was found sufficient for all conditions encountered on the college farm under commercial methods. With average fall temperatures and with an exposure of one minute, four gallons to the hundred would be safe. The higher the temperature and the longer the exposure the weaker should be the solution. Deep submerging of the fruit is not recommended as injury has resulted with this treatment. For this reason machines of the flotation type with shallow tanks are to be preferred.

A Practical Home-made Apple-washing Machine

Hand dipping of apples is neither practical nor desirable in that the fruit is subjected to rough handling and consequently greater mechanical injury occurs. There are many types of machines on the market at present: 1—jet type, 2—flotation, 3—flotation and jets, 4—flooding, 5—combination of flooding and flotation, and 6—the submerger type. This last is not to be recommended as injury occurs to the apples from the entrance of the acid solution thru the open calyx and which cannot be removed by rinsing.

The machine used on the college farm was of the Oregon type which uses the flotation system with paddles for propelling and elevating the fruit. A description of this machine is given in Figures 3 and 4. This machine when properly constructed is suitable for the small grower, is rather inexpensive and not difficult to construct. The elevator paddles must be adjusted so that no rubbing of the fruit occurs at the delivery end and the machine must not be crowded.

That is, only one layer should be run thru at a time. The toweling drapes are the most efficient part of the machine as regards the residue removal.

The machine built on the college farm was 28 inches wide and consistently handled 800 picking-boxes of fruit in 10 hours. Constructed according to the dimensions given in Fig. 4, it should handle 1200 loose boxes in 10 hours. The width of the tank will determine the capacity and the length of the acid tank will govern the time of exposure. The dimensions given should allow about 1 minute exposure. Under these conditions with average fruit 1 gallon of acid to 100 gallons of water should be sufficient to remove the residue below .01 of a grain of arsenious oxide. The paddles should not be run at more than 4 revolutions a minute as a greater speed will cause excessive pumping and injure the fruit. A suggested change would be to use a wide rubber belt with perforations for elevating the fruit in place of the paddles. However, this would be more expensive. A machine built according to the dimensions given will cost from $75.00 to $100.00, depending on whether or not the grower does his own carpenter work and the kind of lumber used. With prevailing prices of labor and lumber on the Western Slope, the machine can be built of redwood for the larger sum named, including carpenter hire.

Bill of Materials

Lumber:

6	pieces	2x12—18 ft. Sides and bottom of tank. Redwood, spruce or fir.
3	"	2x10—4 ft. 4 in. Ends and partition.
2	"	2x10—6 ft. Sides for rinse tank.
7	"	2x4 —4 ft. 4 in. Pine or fir. Cross supports.
3	"	1-2 in. by 13-16 inch parting stop 18 ft. long. For joints.
6	"	2x4 —3 ft. 6 in. Pine or fir. Legs.
4	"	2x4 —4 ft. 3 in. Legs. Pine or fir.
2	"	2x4 —5 ft. Pulley base. Pine.
4	"	1x4 —10 ft. Bracing. Pine.
2	"	1x4 —14 ft. Bracing. Pine
10	"	1x4 —4 ft. Toweling supports. Pine.
12	"	1x10—3 ft. 6 in. Pine. Submerger paddles.
6	"	6x6 —3 in. Submerger paddles.
12	"	1x8 —3 ft. 6 in. Elevator paddles. Pine.
24	"	1x3 —22 in. Elevator paddles.

Miscellaneous:

2 pieces linoleum 3 ft. 8 in. by 2 ft. 6 in. Concaves.
Lumber for concave supports.

Hardware:

9 sprockets.
40 ft. chain.
5 pieces ¾-inch pipe or steel shaft. 4 ft. 8 in.
Rods, bolts, nails and reduction pulleys.

In constructing the tank, all tie rods should be on the outside, bolts and nails counter sunk and heads covered with beeswax, grafting wax, coal tar or paraffin; all metal parts painted with asphalt paint and the tanks with linseed oil or varnish (Oregon Agric. Exp. Sta. Cir. of Information 15).

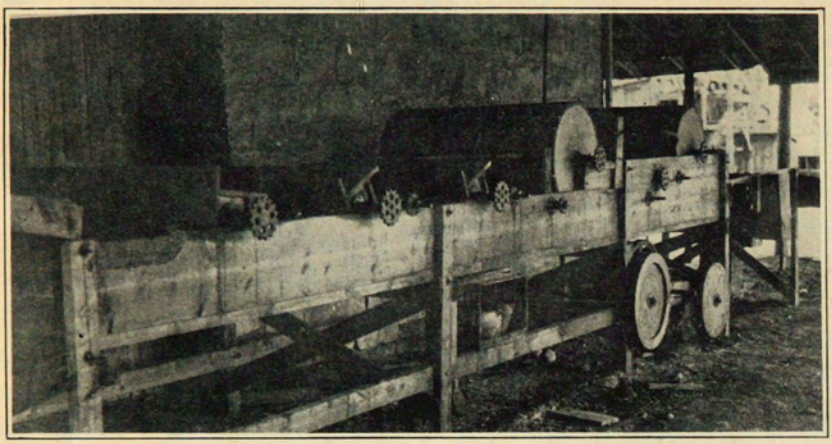


Figure 3.—Oregon-type apple washer with drive chain removed. Speed reduction pulleys shown at lower right-hand end of machine. The construction of the large elevator paddles as shown here is not as desirable or as efficient as the skeleton paddles described in Fig. 4.

The speed at which the fruit travels thru the machine is regulated by the rate of feeding rather than by the speed of the paddles. In this manner the time of exposure can be varied from 1 to 5 minutes, giving a capacity of 2000 to 600 boxes in 10 hours. It would be preferable to use a slightly longer exposure with a weaker acid solution. A solution of 1 gallon of acid to 100 gallons of water with an exposure of 1 and not more than 2 minutes would probably meet average conditions.

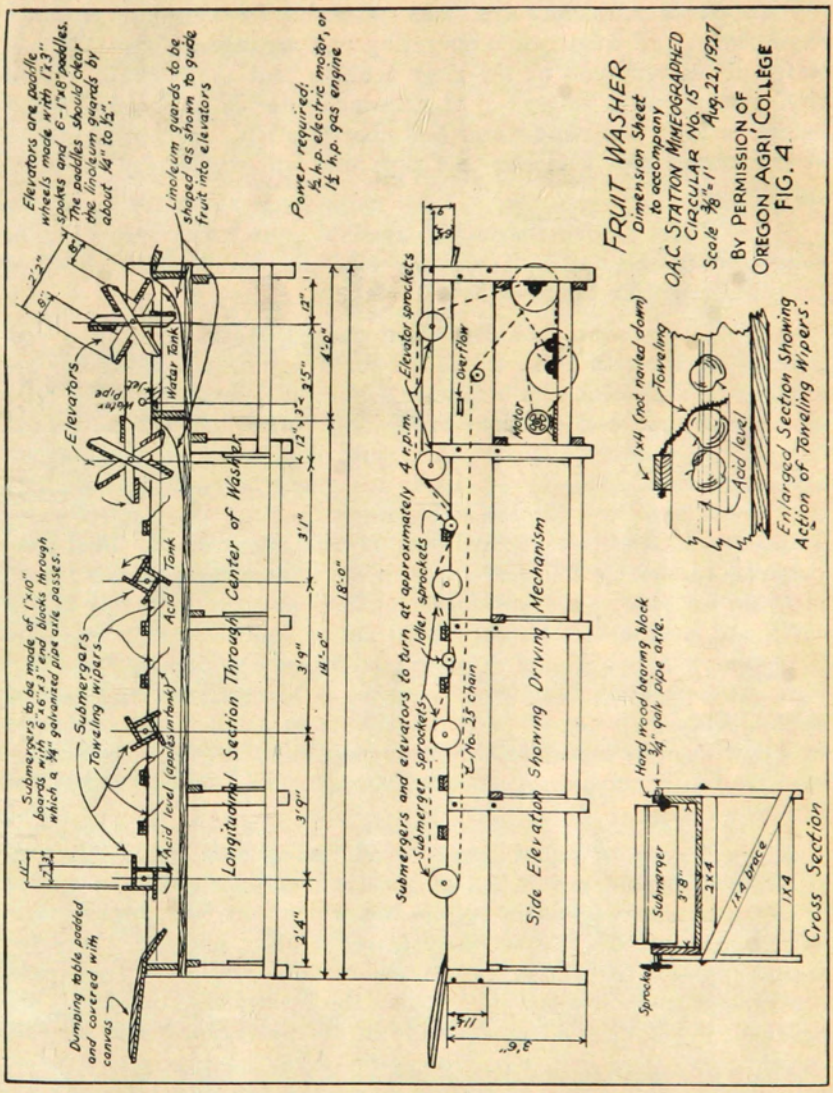
This machine is not suitable for pears as they will not float. This could be remedied by installing a rubber conveyor belt in place of the paddles.

No drier is included as the grower can air-dry the fruit after washing, improvise one from a good dry-wiper, or purchase a ready made drier. For the large grower or shipper and where the handling of the fruit must be continuous, one of the manufactured machines equipped with a drier will prove more satisfactory. All of these have been improved during the last year and have given satisfactory service.

Recommendations

1.—Harvest fruit, both pears and apples, when mature and handle with care to prevent any stem-punctures, broken skins or bruises. Pick all apples with stems on. This will prevent the entrance of decay at this point.

2.—Wash fruit within a short time after picking. If apples are to be stored loose in boxes wash before storing.



3.—It will prove profitable to sort out all culls and decayed fruit before washing.

4.—Use no stronger acid solution than required to remove the residue. This can be determined by running sample lots thru the machine and having them analyzed.

5.—Change acid solution often. At least once a day with small runs, or after every carload with larger runs.

6.—Rinse fruit thoroly. Have fresh water running thru the rinse tank at all times when operating and arrange a spray of fresh water at delivery end of the rinse tank so that fruit will receive a final rinsing as it emerges. If running water is not available use baking soda in the rinse water and change often. Bordeaux nozzles or perforated pipe attached to a pipe line will suffice for the rinse spray.

7.—Where a pipe line is not available, the water spray can be connected to the outlet of a spray machine, the tank being filled from an irrigation ditch.

8.—If apples are not dry when packed, stack boxes in a cool place and expose to a current of air for a day or so. However, wet apples are disagreeable to handle in sorting and some attempt should be made to dry them previous to packing. As noted previously, unless storage conditions are at their best, decay can be increased by excess moisture. This is very likely to occur with high temperatures and lack of aeration. On the college farm the fruit was perfectly dry within two hours, when stacked loose in boxes immediately after coming from the washer. When hand dipped, it requires a greater length of time for drying as considerable free moisture remains in the calyx and stem ends. Apples should not be loaded directly into cars if packed wet, but placed in some kind of cool storage within short time after packing. Immediate storage is necessary in any case as apples held at 70 degrees will deteriorate to about the same extent in a few days as in several weeks storage at 32 degrees. Soft overripe fruit will not improve in cold storage. This merely checks the rate of ripening.

9.—The use of paper wraps is advised as this tends to retard ripening, prevents excessive transpiration, and prevents the spread of decay to otherwise sound apples but which may have broken skin. Stem punctures are not so likely to occur after packing where the wraps are used. In comparing the amount of decay in wrapped and unwrapped packs it was found that in the former case the decay was confined to the original apple while in the unwrapped pack the decayed apples were nested in groups, the decay having spread to the surrounding apples thru punctures which also occurred after packing and during the lidding process.

10.—Finally it should be remembered that apples and pears picked when mature, carefully handled, washed and dried, and placed in cold storage shortly after packing, will not deteriorate in storage to any greater extent than unwashed fruit. The keeping quality may even be improved by washing and the sorting is made easier and less expensive.

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Summary

Storage tests indicate that washing apples in weak strengths of hydrochloric-acid solution does not affect the keeping quality of fruit when properly handled.

The use of disinfectants in the acid solution did not prevent or decrease the amount of decay.

Packing the fruit with a small amount of moisture does not cause or increase decay when stored under ventilation and at low temperatures, and where contamination is not excessive previous to washing.

Such physiological troubles as internal breakdown, scald, and shriveling are not due to the washing process.

It was impossible to distinguish any difference between washed and unwashed apples by taste, sight or touch.

The use of cold sal-soda solution does not affect the keeping quality and is not as efficient as the acid solution in removing the residue.

Fruit must be thoroly rinsed to remove the acid. Where plenty of fresh water is not available, baking soda should be used in the rinse water to neutralize the acid. Acid solution must be changed frequently to prevent excessive accumulation of free arsenic.

Calyx and stem-end discoloration is due mostly to free arsenic accumulating at these points while fruit is on the tree. It is not very intensive in this section.

Actual cost of washing on the college farm during the past season averaged 2½ cents per packed box. This varies with the tonnage handled.

Fruit can be air-dried in boxes in a relatively short time tho this makes for increased handling and delay in packing. Under

commercial conditions fruit should be dried as thoroly as possible and equipment should be sufficient for rapid handling without crowding.

An efficient and practical washer for apples can be constructed by the small grower at no great cost. Hand dipping of apples is not desirable or practical.

Injury is due mostly to over-ripe fruit, rough handling, contamination of acid solution from decayed apples, delay in washing and the resultant use of excessively strong acid solutions, failure to rinse thoroly, lack of frequent changing of acid solution and the resultant accumulation of free arsenic, failure to store promptly and too high temperatures in cars under standard ventilation with early fall shipments.