Marketing Research Report No. 538

chemical control of Scald on APPLES

GROWN IN EASTERN UNITED STATES

Agricultural Marketing Service
Market Quality Research Division
U.S. DEPARTMENT OF AGRICULTURE

PREFACE

The study on which this report is based is part of a continuing research program by the Agricultural Marketing Service to improve the maintenance of quality and to reduce spoilage losses of agricultural products during marketing.

Carl Vaught and Chester Parsons of the Horticultural Crops Branch, Market Quality Research Division, assisted in collecting data.

S.A. Heisey and Sons, Greencastle, Pa.; H.F. Byrd, Inc., Charles Town, W. Va.; Consolidated Orchard Co., Paw Paw, W. Va.; and Moore and Dorsey, Inc., Berryville, Va., provided fruit and the use of their storage facilities for some of the tests. The following companies provided experimental materials: Monsanto Chemical Co., Allied Chemical Corp., Chemley Products Co., American Cyanamid Co., United Paper Co., and Shell Oil Co.

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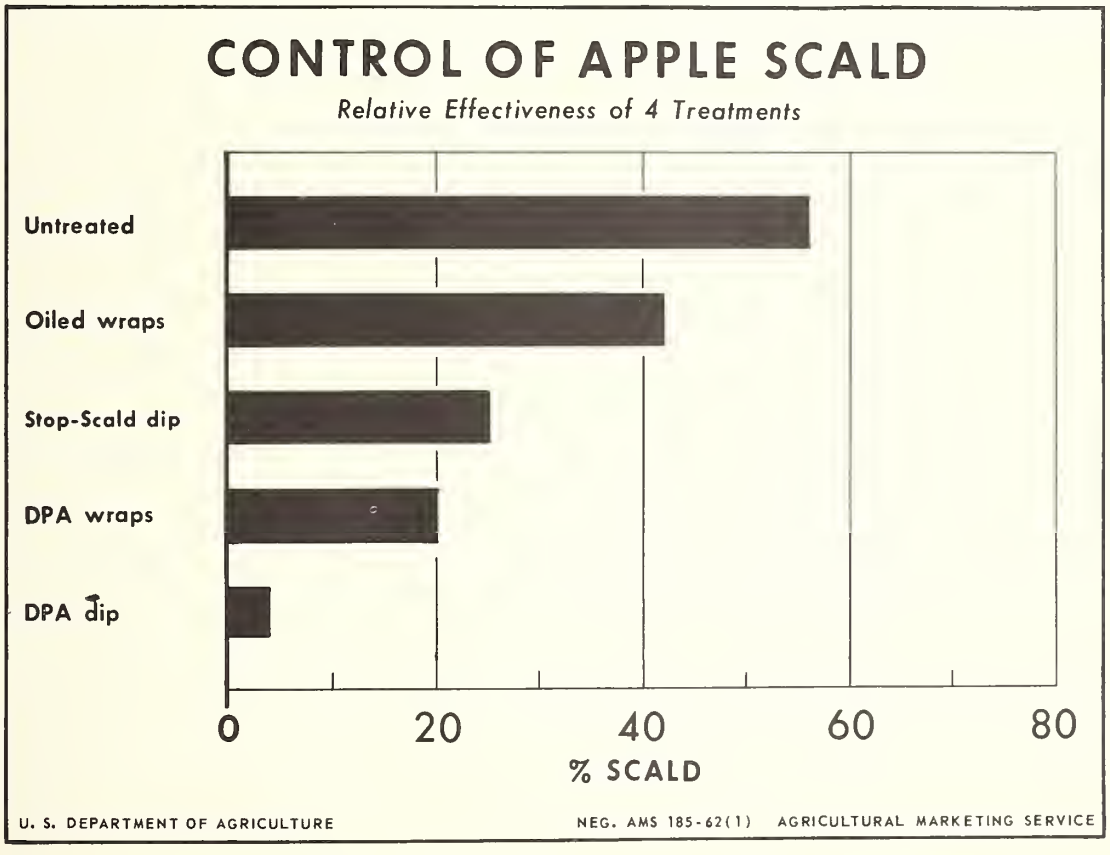
SUMMARY

Diphenylamine (DPA) and ethoxyquin (Stop-Scald), both previously reported as effective inhibitors of scald on apples, controlled scald much better than conventional oiled-paper wraps in tests with eastern-grown apples. Treatment with DPA gave the most complete control.

Dipping apples for a few seconds in a tank containing DPA or Stop-Scald was the most satisfactory method of obtaining good chemical coverage, necessary for scald control. Good control was obtained also by using a drip-type brush applicator, tested on Red Delicious and Stayman apples, and also by spraying or drenching filled field boxes. Tree sprays 1 day before harvest with 2,000 p.p.m. (parts per million) DPA or 2,800 p.p.m. Stop-Scald gave poor protection from scald compared with postharvest treatments.

Two types of DPA-treated wraps, 1.5 mg. DPA wraps (not oiled) and 1.5 mg. DPA oiled wraps, were strikingly superior to oiled wraps without DPA for scald control. For most varieties, DPA wraps containing mineral oil were superior to plain DPA wraps.

A wettable-powder formulation of DPA largely eliminated chemical injury to apples, frequently caused by alcohol solutions of DPA. Stop-Scald caused no injury when used as a postharvest treatment, but preharvest sprays often left brown residue spots on the lower sides of apples. The chart below shows the average extent of scald in 18 tests with several varieties of apples after 5 or 6 months' storage at 31° to 32° F.



Dip treatments were most effective for scald control if given within a few days after harvest, but were usually still quite effective if given after 1 or 2 weeks in storage. Brushing or wiping treated apples while still wet or after drying about an hour reduced scald control in a severe scald year, indicating that some of the chemical was removed. Red Delicious apples dipped in DPA or Stop-Scald could be brushed after 2 weeks or washed after 4 weeks without losing scald control.

Good coverage with Stop-Scald was necessary for effective scald control. Coverage was improved, as indicated by Stop-Scald fluorescence under ultraviolet light, by lengthening the time in the treating tank, increasing the emulsion concentration, or raising the emulsion temperature to 80°, 100°, or 120° F. Coverage was better on warm fruit (70°) than on cool fruit (40°).

Neither DPA nor Stop-Scald influenced firmness, decay, or flavor, or was otherwise detrimental to apple storage life.

The use of scald inhibitors is recommended on varieties likely to scald during late storage. Stop-Scald was effective as a brief postharvest dip or spray treatment at about 1,800 p.p.m. Good scald control is possible with 1.5 mg. of DPA in oiled wraps or with a postharvest dip or spray using wettable-powder formulations of DPA. DPA concentrations of 1,000 or 2,000 p.p.m. were adequate for the eight varieties tested.

Stop-Scald was approved by the Food and Drug Administration for use on apples in 1960. In January 1962, DPA received limited clearance for use on apples with a residue tolerance of 10 p.p.m. This clearance limits the use of DPA to preharvest tree sprays or to postharvest use of impregnated tissue wraps.

CHEMICAL CONTROL OF SCALD ON APPLES GROWN IN EASTERN UNITED STATES

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BACKGROUND

Apple scald, a superficial physiological disorder characterized by irregular-shaped brown blotches on the skin of apples, is a major source of loss during the late part of the storage season in the United States. The browning may be very light in some seasons on some varieties, or it may be severe and may progress until most of the surface is dark brown or almost black. Sometimes affected areas become rough and slightly depressed. Scald in its early stages may not affect dessert quality of apples, but it does make them less attractive.

Scald seldom develops on most varieties of apples stored only 2 to 3 months. After 4 to 6 months, scald may be evident on susceptible fruit in cold storage. When this fruit is removed from storage, the scald symptoms develop rapidly at warm temperatures and the fruit becomes unmarketable or must be sold at a discount.

An immense amount of information about scald is available, as it has been widely studied for over 50 years. However, the cause is still unknown, although it is often associated with immaturity of fruit at harvest.

Since the work of Brooks, Cooley, and Fisher (1)[1] in 1919, oiled-paper fruit wraps have been the principal commercial means of providing protection from scald. These wraps contained 15 to 20 percent of their finished weight in odorless, tasteless mineral oil. Oiled wraps often only reduced scald and gave unsatisfactory control. In a severe scald year, such as the 1959-60 season, they were of little value. Therefore, the search for a better method of controlling scald continued.

Smock (19, 20, 21), in screening chemicals for scald control, found that diphenylamine (DPA) and 1, 2-dihydro-6-ethoxy-2, 2, 4-trimethylquinoline (ethoxyquin) markedly inhibited scald. Ethoxyquin was given the name "Stop-Scald"[2] in 1960. Since the report by Smock in 1955, DPA and Stop-Scald, particularly DPA, have been widely evaluated in the United States (2, 8, 9, 14, 15, 18, 21, 22, 26), Canada (5), Australia (7, 12, 13, 25), New Zealand (3, 10, 16, 17), South Africa (6), England (4), Holland (23), Germany (11), and Switzerland (24). These published reports tell how effective the scald inhibitors were on local varieties, and describe methods of application and residues after various time intervals with different methods of application. Martin (12) developed a method of treating apples in a tunnel with a steam-distillation technique for coating apples with DPA. Denmead et al. (3) described a method of treating loose-packed apples in bushel boxes by drenching with an oil-water emulsion containing DPA. Other workers evaluated DPA-impregnated wraps and preharvest sprays.

In 1960, Stop-Scald was cleared by the Food and Drug Administration for use on apples with a residue tolerance of 3 p.p.m. (parts per million). Possible methods of application include a preharvest spray at 3 pints per 100 gallons (2,700 p.p.m.) within 2

[1] Underscored numbers in parenthesis refer to items in Literature Cited, p. 28.

[2] Use of brand names in this report does not constitute endorsement of the product named or imply discrimination against other products.

days of harvest, or a postharvest dip or spray at 2 or 3 pints per 100 gallons (1,800 or 2,700 p.p.m.). Shipping containers for treated apples must be labeled with a statement such as "Ethoxyquin added as a preservative." Cost of the Stop-Scald is 1 cent or less per bushel for dipped fruit, and only 1/2 cent per bushel with a drip-brush applicator. The total cost of material plus labor and equipment for treating fruit in a dip tank may be nearer 5 cents a bushel. Tree sprays are more expensive because more chemical is wasted in spraying.

Toxicity studies with DPA were completed in 1961 and a residue tolerance of 10 p.p.m. on apples was established by the Food and Drug Administration in 1962. The clearance for use of DPA on apples was limited to preharvest sprays or to treated tissue paper wraps for postharvest use. Harvey and Clark (10) found that 90 percent or more of the DPA residue on treated apples was in the outer 2 to 4 mm. of tissue. Residues after 3 to 7 months' storage were 3 p.p.m. or less. Hall, Scott, and Coote (7) found residues from a 1,000-p.p.m. DPA dip to be 7 to 8 p.p.m. after 1 day, but only about 0.3 p.p.m. after 7 months. Somewhat similar results were reported by Bruce, Howard, and Zink (2), who found that a 1,000-p.p.m. DPA dip left an initial residue of about 3.5 p.p.m. which declined to 1.1 to 1.7 p.p.m. after 4 to 5 months' storage.

Evaluation of chemical scald inhibitors at Beltsville, Md., was begun in 1956. This report summarizes trials during five storage seasons. The objective was to determine the value of DPA, Stop-Scald, and other materials on scald-sensitive varieties grown in the Cumberland-Shenandoah area of Virginia, West Virginia, Maryland, and Pennsylvania, using different treating methods.

METHODS

Storage.--Fruit usually was treated and packed either the same day it was harvested or the following day, and then stored at 31° to 32° F. and 85 to 90 percent relative humidity. In some tests, treatment was delayed intentionally 1 to 4 weeks for comparison with immediate treatments. All fruit was composited before treatment and 2 to 4 duplicate boxes (200 to 400 apples) of each treatment were prepared for storage. The storage period averaged 5 to 6 months for most varieties before removal to 70° F. or room temperature (45 to 55 percent relative humidity) for a 6-day holding period for scald development. Grimes Golden apples were stored only 3 1/2 to 4 months before examination.

Wraps and dip treatments.--The basic test consisted of comparing scald development on fruit packed untreated (control), with mineral-oil wraps, with DPA wraps, with DPA oil wraps, and with various DPA dip or spray treatments. Stop-Scald dip and spray treatments were included only in the 1959-60 and 1960-61 seasons.

Freshly made DPA wraps specified to contain 1.5 mg. of DPA per sheet were used each year. Analysis of the 1956 wraps in December, when they were 5 months old, showed that they still contained about one-third of the specified amount. The 1957 wraps analyzed in October (3 months old) contained three-fourths of the specified amount of DPA.

A technical grade of DPA was used for the dip and spray treatments in 1956 and 1957. However, in subsequent years a more highly purified form (essentially A.C.S. Reagent Grade DPA) was used. This recrystallized DPA had a minimum purity of 99.9 percent as determined by cryoscopy. This change in type of DPA during the tests was necessary because the type used in the animal toxicity studies was changed. After several months of feeding, it was found that rats getting the technical grade of DPA in their diet were not gaining weight, as impurities in the DPA apparently kept them from eating. When the purified form was substituted, the rats ate satisfactorily and the toxicity study was completed using the purified DPA.

For dip and spray treatments, the DPA was first dissolved in isopropyl alcohol. The final water suspension had 5 percent of alcohol, 1,000 or 2,000 p.p.m. of DPA, and 0.025 to 0.1 percent of Tween-20 as a wetting agent. This suspension was vigorously agitated before use either as a dip (the fruit was dipped repeatedly for 10 to 15 seconds in rubber-covered wire baskets) or before spraying over fruit. Upon removal from the dip, apples were allowed to drain briefly before they were packed into wooden boxes or corrugated cartons.

Frequently, apples treated with the alcohol solutions of DPA showed some chemical injury after storage. Other workers had found that injury was largely prevented with wettable-powder formulations, so a 42-percent wettable-powder DPA was included in the 1960 tests.

The Stop-Scald was a 70-percent commercial formulation containing 6 pounds of ethoxyquin per gallon. It was tested at concentrations of 900 to 3,600 p.p.m. An 80-percent formulation was included in a few tests.

Postharvest box sprays were applied by spraying or flooding one liter of test material over each filled field box.

Fruit examination.--After removal from cold storage, apples were examined for scald, decay, chemical injury, firmness, odor, and general condition. A second examination was made after the 6-day holding period at 70° F. During this holding period, the fruit was still in boxes, but with all fruit wraps, if any, removed. For brevity, only data for the second examination are presented. Scald was rated as slight if 10 percent or less of the surface of the individual apple was affected, moderate if 10 to 25 percent was affected, and severe if more than 25 percent was affected. Only severe and total scald are shown in the results.

Firmness was measured with a Magness-Taylor pressure tester with a 7/16-inch plunger, using 20- or 30- fruit samples.

RESULTS AND DISCUSSION

All DPA dip and spray treatment results shown in the tables (starting on p. 30) are those when alcohol solutions of DPA were used, except when a wettable-powder formulation is indicated.

Red Delicious Apples

Good control of scald with chemicals was more difficult to achieve with Red Delicious apples than with some other varieties. Conventional mineral-oil wraps frequently provided little or no scald control (tables 1-3 and fig. 1). Individual wraps containing 1.5 mg. of DPA per sheet or 1.5 mg. of DPA with mineral oil were much superior to oiled wraps without DPA. The best wrap for scald control on Delicious apples was the DPA oiled wrap. Neither of the two types of DPA wraps caused any injury to the fruit. In a severe scald year such as the 1959-60 season, none of the fruit wraps provided good scald control on Delicious apples (table 2).

In one test (table 3), scald was even more severe on fruit stored with oiled wraps or with DPA wraps than on the control fruit without wraps, but this was an exception to all the other tests.

Figure 2 shows the value of oiled wraps used in conjunction with a postharvest chemical dip. While such a double treatment is more costly, it gave the best scald control.

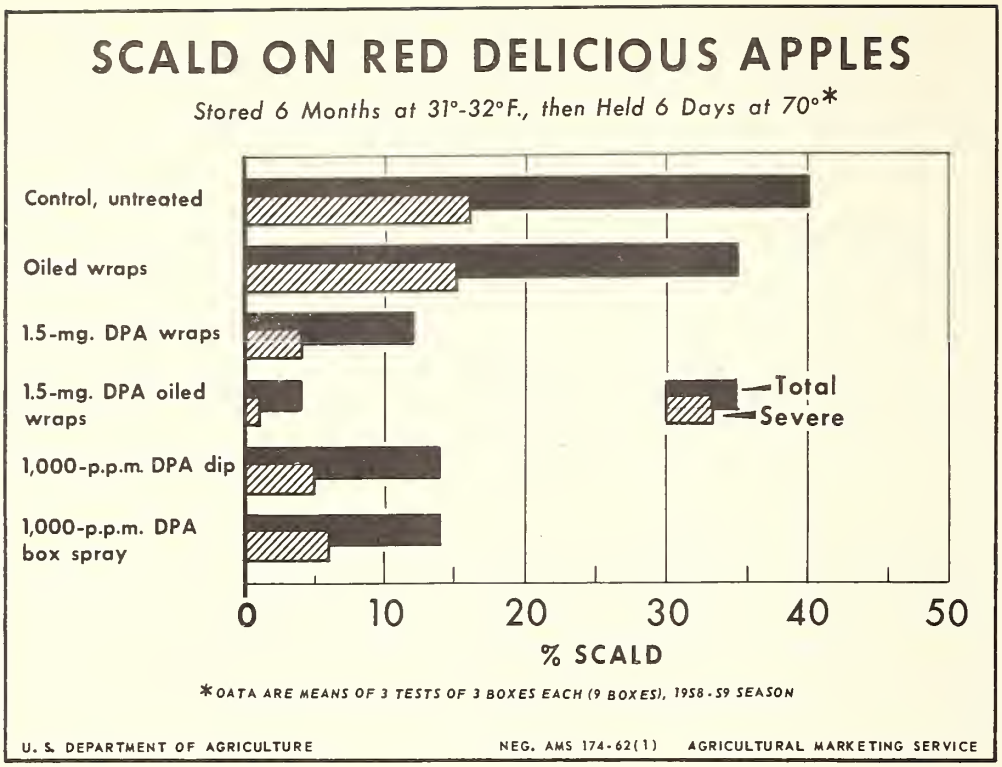

Figure 1

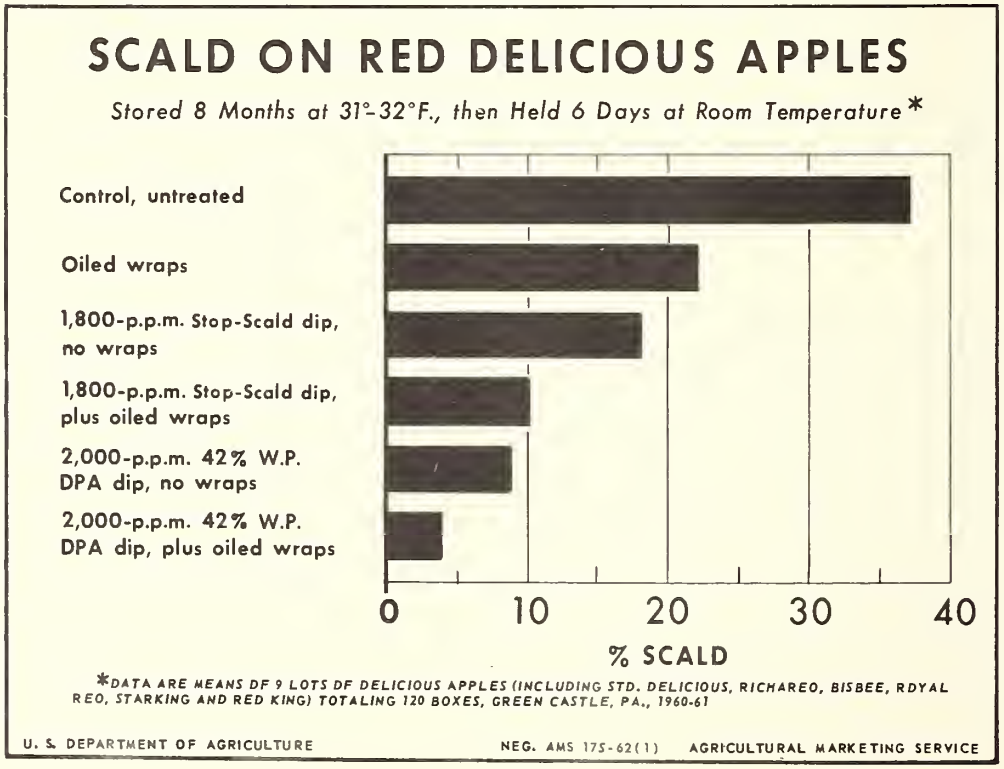

Figure 2

DPA wraps were added 0, 1, 2, and 4 weeks after harvest in one test to determine the protection provided by late application (table 2). However, in that test DPA wraps gave poor scald control regardless of time of application, so the loss of effectiveness with delayed wrapping could not be determined.

DPA and Stop-Scald were evaluated as postharvest dip treatments of 10 to 15 seconds in several tests (tables 1-5, 7-9, figs. 1, 2). Both 1,000-p.p.m. and 2,000-p.p.m. DPA dips gave good scald control in most tests. In seasons when scald was extensive, a 2,000-p.p.m. DPA dip provided better scald control than 1,000 p.p.m. A 2,000-p.p.m. DPA dip often prevented severe scald. It was usually the most effective treatment for scald control on Red Delicious apples, being slightly more effective than DPA oiled wraps.

Stop-Scald as a dip was less effective than a DPA dip for scald control in a year of severe scald. However, Stop-Scald often satisfactorily controlled scald on Red Delicious apples. It was consistently better than oiled wraps. An 1,800-p.p.m. Stop-Scald dip (2 pints to 100 gallons) was better than 900 p.p.m. In two tests (tables 3, 4), 3,600 p.p.m. Stop-Scald as a dip was no better than 1,800 p.p.m. Figure 2 illustrates some results with several strains of Red Delicious. Extent of scald after storage was 37 percent on untreated apples, 22 percent with oiled wraps, 18 percent with an 1,800-p.p.m. Stop-Scald dip, and 9 percent with a 2,000-p.p.m. DPA dip.

Neither DPA nor Stop-Scald hastened loss of firmness or damaged flavor.

Several acids tested as dips at 2,000 p.p.m. were not as effective as DPA in controlling scald (table 3).

Delayed treatment of Delicious apples with a DPA or Stop-Scald dip after a period in storage was evaluated in several tests (tables 2, 3, 5, 8). When fruit was stored 2 weeks at 31° to 32° F. and then dipped in 2,000-p.p.m. DPA or in an 1,800- or 2,000-p.p.m. Stop-Scald, control of scald was still good to excellent (tables 3 and 5). When treatment was delayed as much as 4 weeks after harvest, the chemicals were less effective, although scald reduction was still appreciable. A DPA dip treatment applied after 4 weeks' storage was more effective than a Stop-Scald treatment applied at that time (table 5). Scald on fruit treated with Stop-Scald 7 weeks after harvest was not controlled, but there was still an inhibitory effect (table 8).

Pierson and Schomer (18) found that the effectiveness of a DPA dip is reduced when treatment is delayed even 1 week, although Delicious apples treated 3 or 4 weeks after harvest developed less scald than those protected with oiled wraps immediately after harvest.

DPA and Stop-Scald also were successfully applied to Delicious apples with a drip-type applicator using a large revolving brush. Scald control as good as that produced by a complete dip was possible with the drip applicator (table 5).

Postharvest spray treatments, in which a liter of 2,000-p.p.m. DPA or 1,800-p.p.m. Stop-Scald was sprinkled over each box, also were effective in controlling scald (tables 1-3, 5). Such spray applications have commercial possibilities for use in packing plants. The chemicals could be sprayed on fruit on conveyor rollers or in boxes as the apples moved along a belt. However, Harvey and Clark (10) have shown that postharvest box sprays leave slightly higher residues on fruit than dip treatments. The box sprays gave much better scald control than that obtained with oiled wraps, and a DPA box spray was slightly better than a Stop-Scald box spray (table 3).

Preharvest sprays applied 1 day before harvest to Red Delicious apples provided little scald protection (tables 1, 2, 6). In two of three tests, a 2,000-p.p.m. DPA spray reduced scald more than a spray with 2,800-p.p.m. Stop-Scald, but neither was nearly as effective as a postharvest dip with these chemicals. Neither Stop-Scald nor the 42-percent wettable-powder DPA applied as a preharvest spray caused any chemical

injury, but both left some objectionable residue marks on the apples, which might necessitate later washing or brushing.

Apples harvested and then allowed to color for 7 days on straw placed under the trees and then dipped in DPA or Stop-Scald developed little scald. Similar apples not chemically treated following sun coloring developed considerable scald (table 5).

The effectiveness of the two scald inhibitors was still apparent when fruit was brushed or washed as early as 2 to 4 weeks after treatment. When apples were dipped in the chemicals and then commercially brushed as soon as they were dry or partially dry, the effectiveness of the treatment was reduced but still good. Scald control was slightly better when fruit was not brushed until 2 or 4 weeks after treatment. Scald control was good also when DPA- or Stop-Scald-treated Red Delicious apples were washed 4 weeks after treating.

Results of other methods of treating Red Delicious apples with DPA and Stop-Scald are listed in table 5.

Chemical injury from use of alcohol solutions of DPA was noted in some tests with Red Delicious apples. The amount of injury ranged from none to 58 percent. Sometimes it was evidenced as a crystal burn or pitting scattered over the surface. More often the crystal burn was concentrated in stem and calyx cavities. This DPA injury was due to difficulty in maintaining stable suspensions made from alcohol solutions added to water. While good agitation of the suspension reduced injury, floating crystals or clumps of crystals sometimes were picked up by fruit.

Wettable-powder formulations of DPA largely prevent the injury associated with alcohol solutions of DPA. A 42-percent wettable-powder (W.P.) DPA was tested extensively during the 1960-61 season (tables 3, 4, 5, 7). Usually a dip in 2,000-p.p.m. 42-percent W.P. DPA gave as good control of scald on Red Delicious apples as in a 2,000-p.p.m. DPA alcohol solution. All the DPA results shown in table 5 were with the wettable-powder formulation and there was no chemical injury. A 50-percent liquid formulation of DPA also seemed effective without causing injury (table 7). In some tests reported in table 7, scald control was not as good with the wettable-powder DPA or the liquid formulation as with alcohol solutions of DPA. No explanation for this is known.

A 42-percent W.P. DPA often left a slight powdery residue of the carrier on the fruit, which was considered objectionable. The residue might require brushing or washing for removal. An 83-85-percent W.P. DPA is now available and should leave less visible residue.

Wetting agents were used with Stop-Scald or DPA in several tests. Stop-Scald, which contains a wetting agent in the commercial formulation, was not improved for Red Delicious apples when 0.1 percent Tween-20 was added (table 8). Neither was scald control improved when 0.05 or 0.1 percent Tween-20 was added to a 2,000-p.p.m. DPA dip, although the wetting agent reduced burning from DPA (table 9). In some regions with a different water supply, wetting agents might improve coverage with chemical scald inhibitors.

Two commercial wetting agents, Triton X 72 and Tween-20, were tested with Stop-Scald on Richared and Red King Delicious apples in quantities ranging from 2 ounces to 16 ounces per 100 gallons. Although the wetting agents did not improve scald control, they were not injurious to fruit even at the highest rate of application.

Rome Beauty Apples

Rome Beauty is one of the varieties most susceptible to scald. Often scald is very severe on early-picked Rome apples stored more than 3 or 4 months. It is difficult to control with commercial oiled wraps.

DPA wraps and DPA oiled wraps were much better than conventional oiled wraps in controlling scald, as shown in tables 10-14 and figures 3-5. Scald control with the two

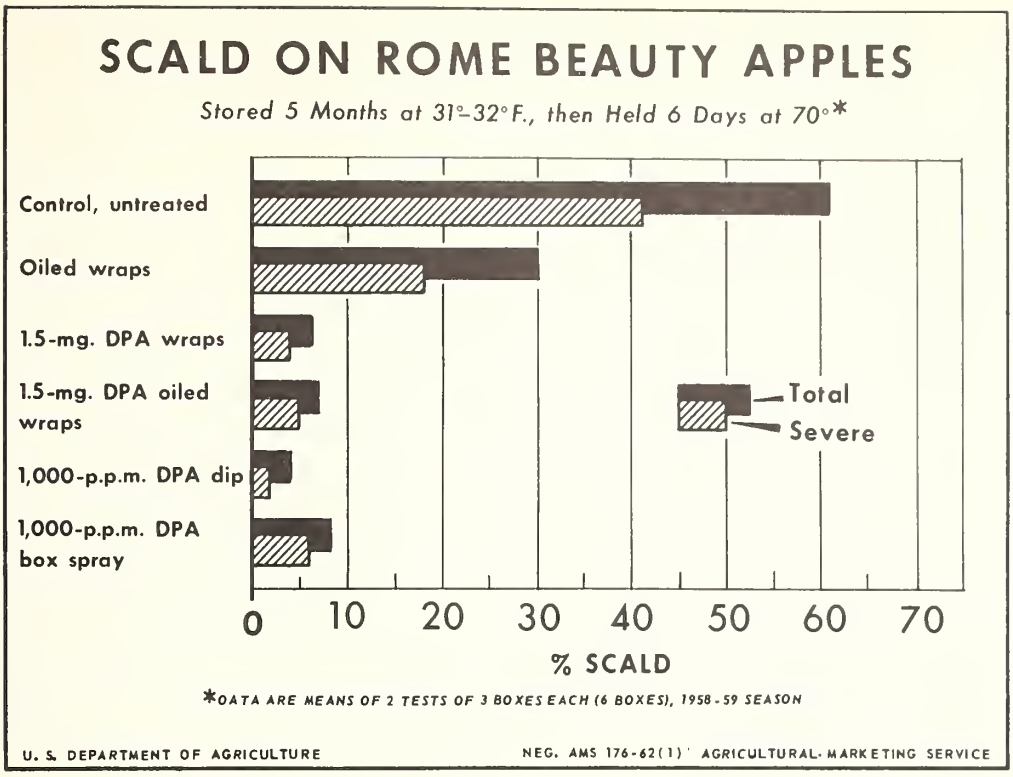

Figure 3

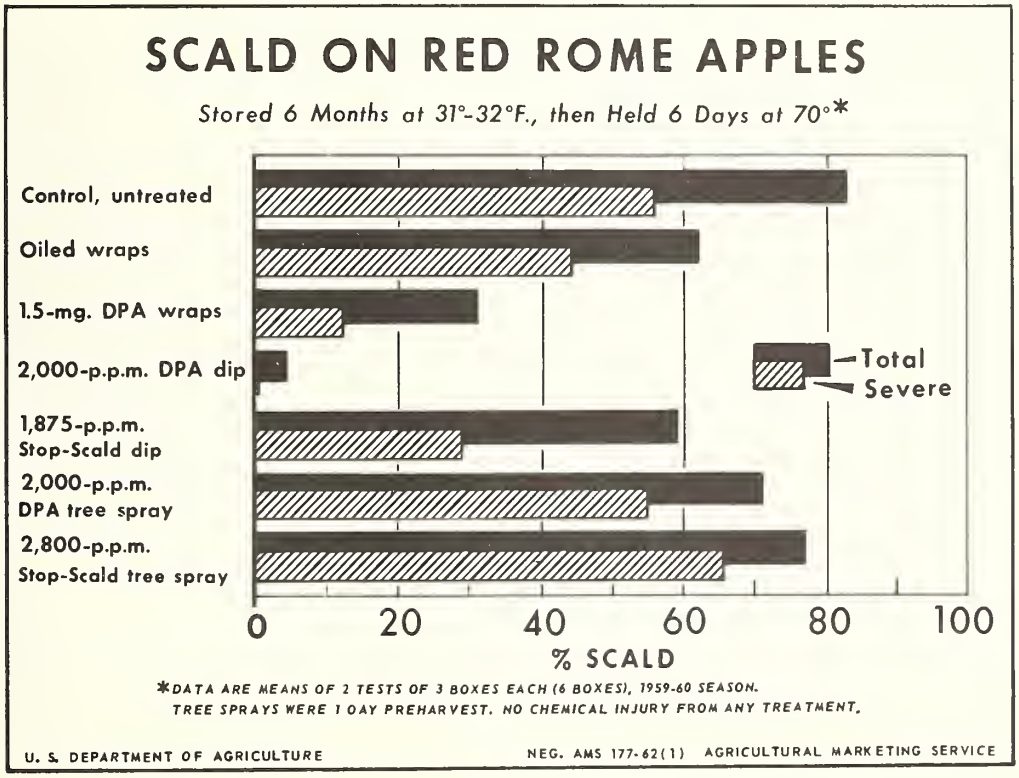

Figure 4

types of DPA wraps was seldom complete, but scald reduction was markedly superior to that obtained with oiled wraps. No bad effects, such as chemical injury, increased decay, or increased rate of softening, resulted from the use of DPA wraps. In 4 of 6 tests where both 1.5-mg. DPA wraps and 1.5-mg. DPA oiled wraps were compared, the DPA oiled wraps gave better scald control. In the other two tests, both types of DPA wraps provided good control (fig. 3).

The 1.5-mg. DPA oiled wraps appear to be the best of the wraps tested for Rome apples. In a test where Rome Beauty apples were stored 5 1/2 months at 32° F. and then held 6 days at room temperature, 75 percent of the control apples (untreated), 40 percent of those in oiled wraps, and only 3 percent of those in DPA oiled wraps were severely scalded (table 14).

DPA wraps used on Rome apples packed in polyethylene-lined boxes reduced scald better than oiled wraps (table 12). When apples were stored 2 weeks before adding DPA wraps, the effectiveness of the wraps was slightly reduced.

The value of a postharvest dip in DPA or Stop-Scald for Rome apples is shown in tables 7, 8, and 10-14, and figures 3 and 4. A 10- to 15-second dip in 2,000-p.p.m. DPA usually gave the best control of scald. For example, figure 4 shows that, of Red Rome apples stored 6 months at 31° to 32° F., untreated apples had 83 percent scald and apples dipped in 2,000-p.p.m. DPA had 4 percent scald. A 2,000-p.p.m. DPA dip usually gave better scald control than a Stop-Scald dip or DPA oiled wraps. A dip in 1,000-p.p.m. DPA controlled scald in some lots of Rome apples. However, in tests where scald was severe, a dip in 2,000-p.p.m. DPA was superior (tables 13, 14). In one lot of apples (table 12), a 2,000-p.p.m. DPA dip was the only treatment giving complete scald control; however, there was some chemical injury (fig. 6) in the form of pitting and skin burning.

Wettable-powder formulations of DPA used as a dip gave poorer scald control than alcohol solutions of DPA, but chemical injury was largely eliminated. A DPA dip treatment for Rome apples, delayed 2 or 4 weeks after harvest, was less effective than immediate treatment, but still gave better scald control than oiled wraps.

DPA treatments, while effective against scald, did not control Jonathan spot, as shown in tables 11 and 12. Polyethylene liners controlled Jonathan spot on Rome apples.

Stop-Scald usually gave good protection from scald when apples were treated in a dip tank (figs. 7, 8) at about 1,800 p.p.m., but often was not as good as a DPA dip. Higher concentrations of 2,800 or 3,600 p.p.m. of Stop-Scald sometimes gave better control. Fruit dipped in Stop-Scald and then wrapped in oiled paper scalded less than fruit that had only the Stop-Scald dip (table 14). Fruit stored 2 weeks before treating with Stop-Scald scalded worse than fruit treated soon after harvest. When treatment was delayed until a month after harvest, Stop-Scald still reduced scald considerably in one test (table 8), but in another it was of little value (table 13). Obtaining good coverage with Stop-Scald on various lots of fruit apparently is most important for effective scald control.

Scald control on apples dipped in Stop-Scald or DPA and then wiped an hour after treatment was poorer than on apples not wiped (table 13).

Postharvest box sprays with 2,000-p.p.m. DPA or 1,800-p.p.m. Stop-Scald controlled scald on Rome Beauty apples nearly as well as a 10- to 15-second submersion in the chemicals (table 14, fig. 3).

Preharvest tree sprays with Stop-Scald and DPA were largely ineffective. In some tests, scald was reduced slightly with sprays applied the day of harvest or 1 day before harvest, but control was much poorer than with dip treatments (table 6, fig. 4). There was little difference in scald control whether apples were picked 1 hour or 24 hours after spraying.

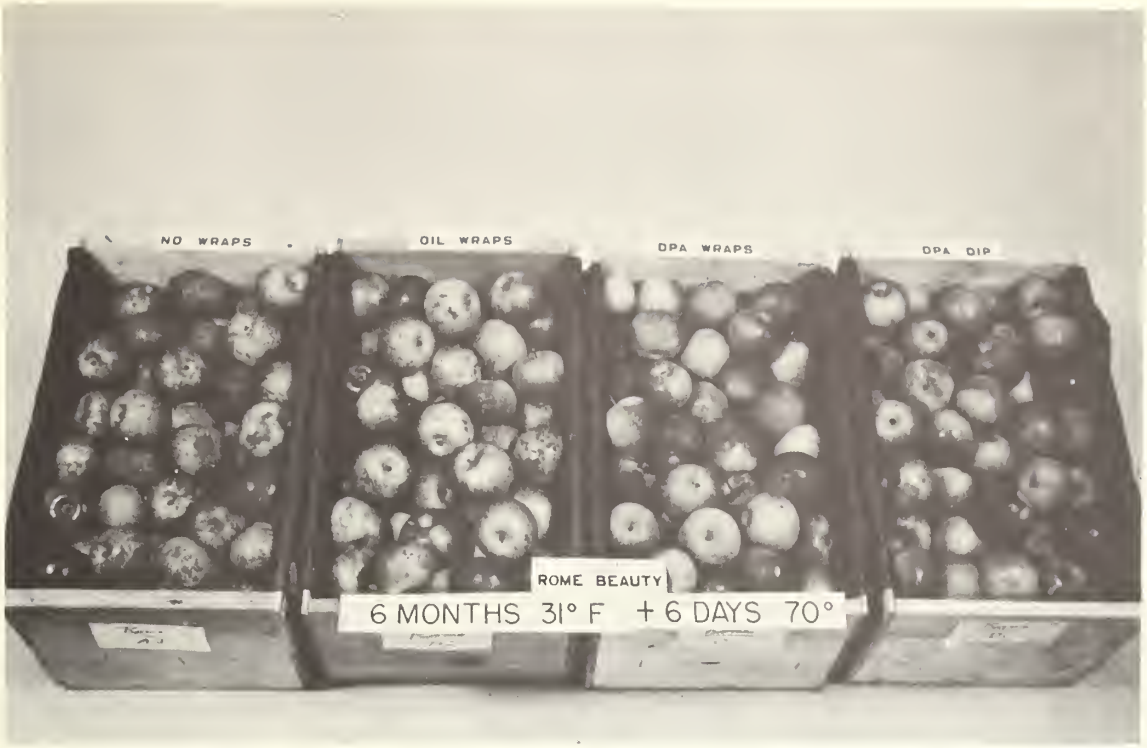

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Figure 5. --Good scald control on Rome Beauty apples was obtained using 1.5-mg. DPA wraps or a 1,000-p.p.m. DPA dip, at the right, compared with nonwrapped or oil-paper-wrapped fruit, at the left.

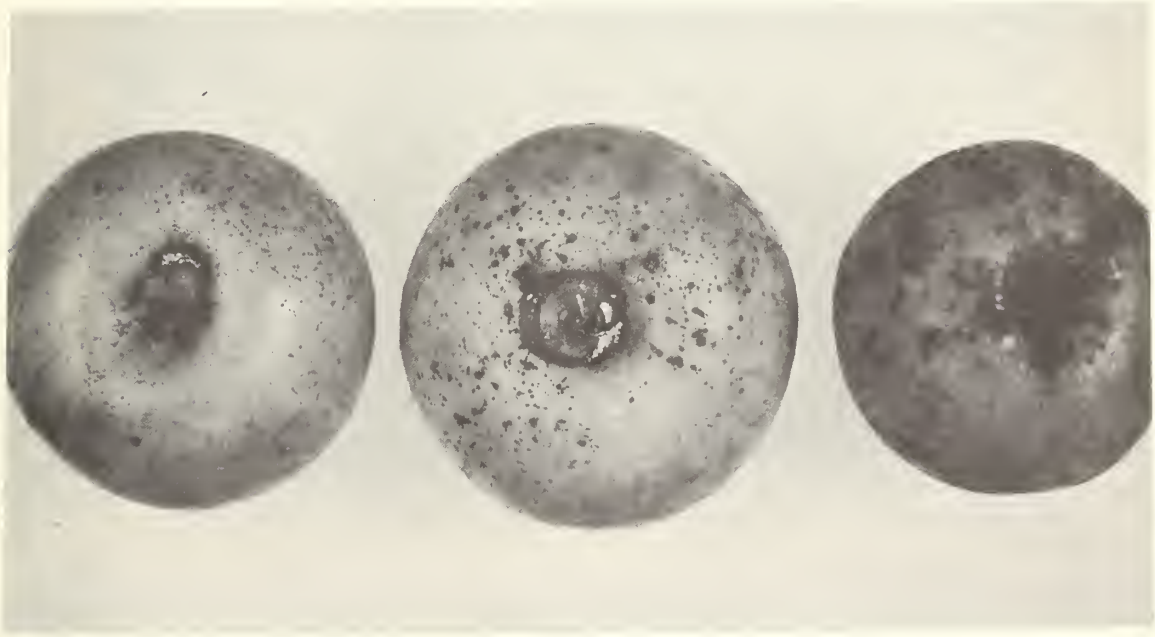

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Figure 6. --Rome Beauty apples showing chemical injury following dipping in alcohol solutions of diphenylamine (2,000-p.p.m. DPA); use of wettable-powder formulations of DPA largely eliminated this injury.

BN-15558

Figure 7.--Treating apples with Stop-Scald in a dip tank following washing and brushing.

Several acids tested as a dip at 2,000 p.p.m. were ineffective in providing scald protection (table 14). The chemical dimethyl- diphenyl-urea (DDU) was ineffective for controlling scald on Rome Beauty apples (tables 13, 14).

Stayman Apples

Chemical inhibitors of scald on Stayman apples were evaluated in eight tests as shown in tables 7 and 15-17, and figures 9 and 10. Use of oiled wraps reduced scald but gave poor control. Both DPA wraps and DPA oiled wraps provided good scald protection on Stayman and Red Stayman apples. Extent of severe scald was 6 percent or less in all tests with the two types of DPA wraps; in some tests development of severe scald was prevented.

Dipping Stayman apples in 1,000- or 2,000-p.p.m. DPA or in 1,800-p.p.m. Stop-Scald gave good scald control. Of the two materials, the DPA dip frequently gave more complete scald control. Neither DPA nor Stop-Scald injured Stayman apples in the concentrations tested or had adverse effects on fruit firmness or flavor. A 42-percent wettable-powder formulation of DPA performed satisfactorily, caused no injury, and did not have the disagreeable odor usually associated with alcohol solutions of DPA (tables 7 and 17, fig. 11). A 50-percent liquid formulation of DPA used at 2,000 p.p.m. also controlled scald.

Apples brushed while still wet 30 minutes after dipping in DPA or Stop-Scald developed more scald than nonbrushed fruit. Apparently some of the chemical was removed in brushing. Scald control on this brushed fruit was better than on that protected with oiled wraps.

BN-15559

Figure 8.--Roller conveyor lifts apples out of tank containing chemical scald inhibitor.

Apples stored 2 weeks before treatment in a dip tank with Stop-Scald or DPA developed slightly more scald than fruit treated immediately. Extent of scald, nevertheless, was still less than on apples with oiled wraps.

Stop-Scald and DPA, applied with a drip-type brush applicator after washing and brushing, controlled scald very well on Stayman apples (table 17).

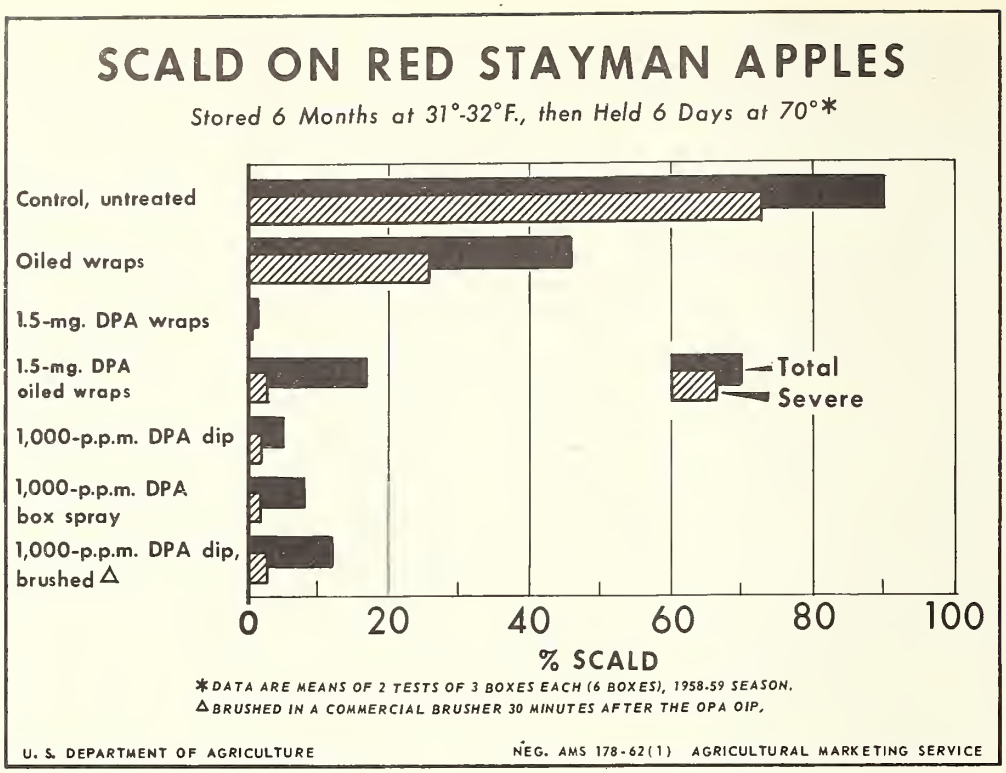

Figure 9

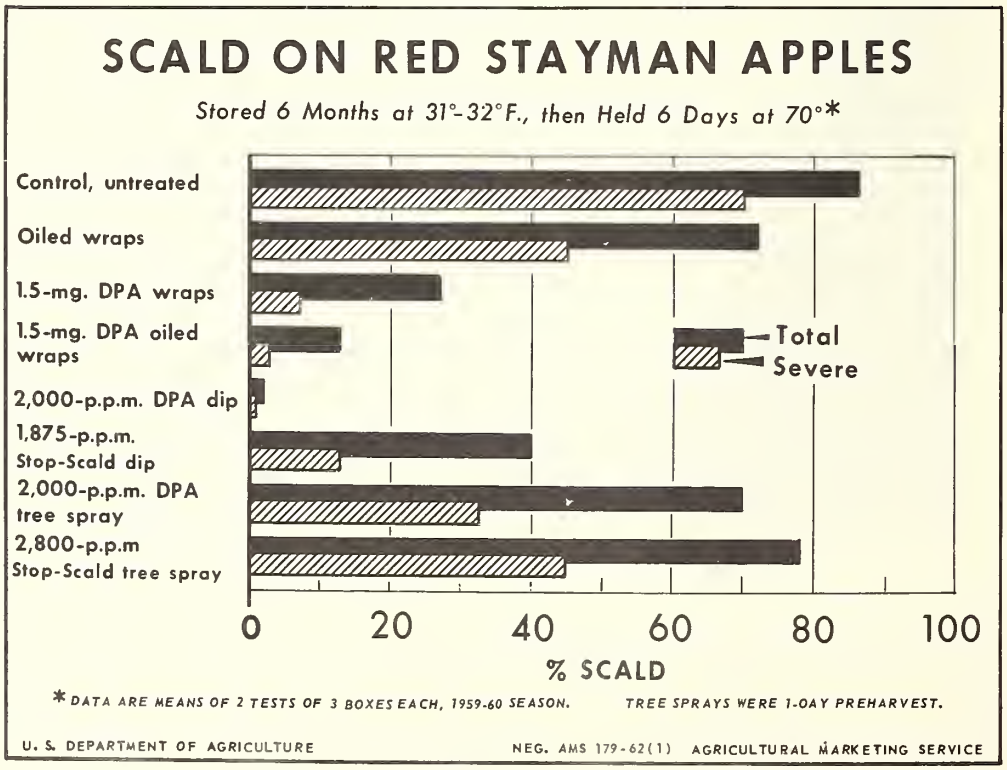

Figure 10

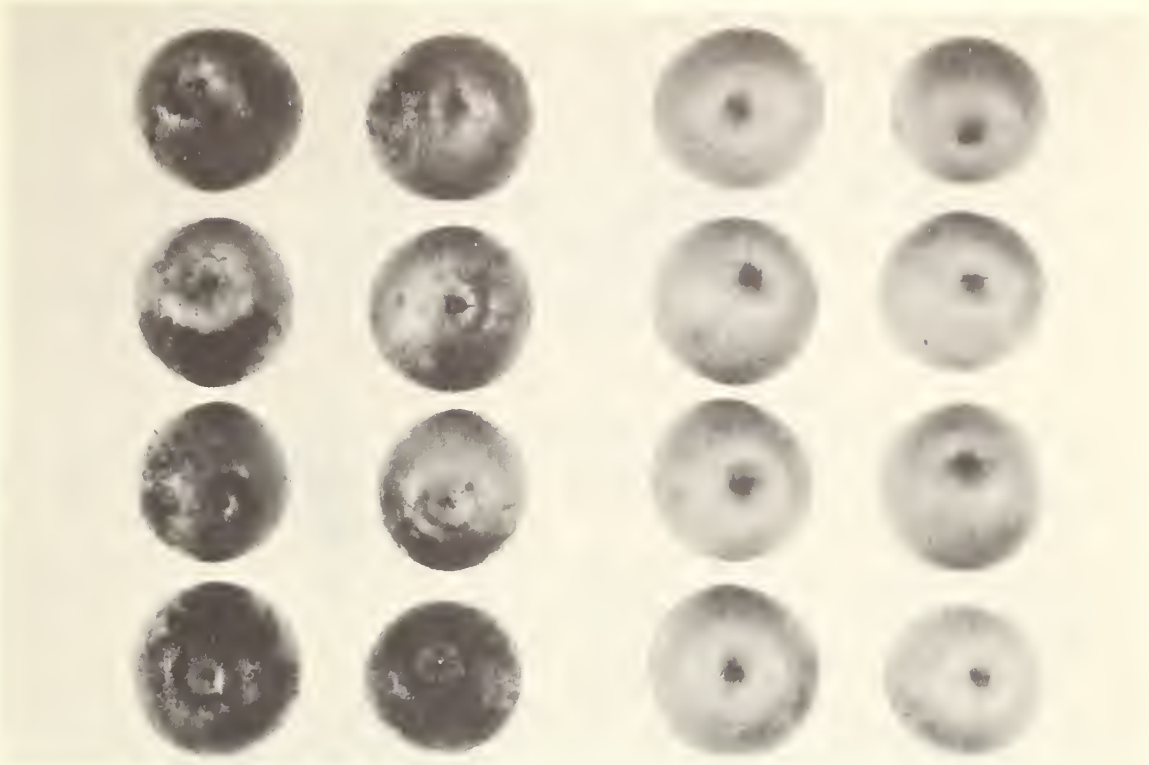

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Figure 11.--Scald control on Stayman apples dipped in 2,000-p.p.m. wettable-powder DPA; untreated left, treated right.

Postharvest box sprays using 1,000-p.p.m. DPA were tested one season. Scald control was good, with only 8 percent of the fruit scalded compared with 90 percent for untreated fruit (fig. 9).

Tree sprays 1 day before harvest with 2,000-p.p.m. DPA or 2,800-p.p.m. Stop-Scald gave little scald control. Treated fruit still was 70 or 78 percent scalded after 6 months' storage (fig. 10).

York Imperial Apples

Data from three seasons' tests with York Imperial apples are included in tables 7, 18, and 19 and figure 12. Scald was less severe and easier to control on this variety than on Delicious, Rome, or Stayman apples. When scald was not extensive, oiled wraps provided fairly good protection. When scald was severe, oiled wraps gave unsatisfactory control (fig. 12).

Use of either DPA wraps or DPA oiled wraps gave nearly complete scald control. These DPA-treated wraps were superior to conventional oiled wraps in controlling scald on York apples. Differences in the effectiveness of the two types of DPA wraps were slight.

Dipping York apples briefly in 1,000- or 2,000-p.p.m. DPA or in 1,800- or 2,000-p.p.m. Stop-Scald largely eliminated scald during storage or subsequent holding. In tests where both 1,000-p.p.m. and 2,000-p.p.m. DPA dips were included, the lower concentration controlled scald adequately (tables 18, 19). Alcohol solutions of 2,000-p.p.m. DPA caused some chemical injury. Wettable-powder formulations of DPA provided scald control without the injury. Stop-Scald dip treatments caused no injury even at a 3,600-p.p.m. concentration, but 3,600-p.p.m. was higher than necessary for scald control.

Fruit brushed within 30 minutes after treatment with DPA or Stop-Scald developed little scald in one test (table 19). In York apples, more susceptible to scald, brushing this soon after treatment with scald inhibitors might reduce the chemical effectiveness.

A postharvest box spray, in which one liter of 1,000-p.p.m. DPA was sprayed over each filled box, provided good scald protection (fig. 12).

Preharvest sprays of DPA and Stop-Scald were less effective for scald control than postharvest dips (table 18). They were also less effective than DPA wraps.

Use of DPA wraps or of DPA or Stop-Scald dips did not hasten loss of firmness or otherwise damage storage quality of York apples.

Arkansas Apples

The Arkansas variety is highly susceptible to scald. In three storage tests at Beltsville, Md., oiled wraps gave poor protection from scald; 80 percent or more of the fruit protected with oiled wraps was scalded after 5 or 6 months' storage at 32° F. and 6 days at 70° (table 20, fig. 13).

DPA wraps or DPA oiled wraps provided excellent scald control when they contained 1.5 mg. of the chemical per sheet. Wraps containing only 0.75 mg. of DPA were better than oiled wraps but less effective than 1.5-mg. DPA wraps. Wraps specified to contain 2.0 mg. of DPA were no better than 1.5-mg. wraps.

The 1.5-mg. DPA wraps provided excellent scald control for Arkansas apples stored in polyethylene-lined boxes. Even within nonsealed or perforated polyethylene liners, which often accentuate scald development, the DPA wraps controlled scald almost completely (table 20). One-year-old DPA wraps were included in one storage test. These old wraps had lost most of their effectiveness.

Dipping Arkansas apples in 1,000- or 2,000-p.p.m. DPA controlled scald strikingly well. Table 20 shows that 97 percent of the untreated apples scalded, while none of those dipped in 2,000-p.p.m. DPA scalded. Scald control was nearly complete with a 1,000-p.p.m. DPA dip.

Arkansas apples were not injured by DPA wraps or dip treatments.

Grimes Golden Apples

Scald on Grimes Golden apples was quite easily controlled with chemical inhibitors. Even oiled wraps reduced scald more than on most varieties tested. DPA wraps and DPA oiled wraps were superior to oiled wraps in controlling scald, as shown in tables 21-23 and figure 14. Both types of DPA wraps gave equally good control and eliminated scald classified as severe. Even within perforated polyethylene liners, 1.5-mg. DPA wraps completely controlled scald while 74 percent of the untreated Grimes Golden apples scalded (table 22).

Dipping apples in DPA or spraying after harvest controlled scald almost completely. A 1,000-p.p.m. DPA dip was adequate for scald control on this variety (fig. 14 and table 22). A 2,000-p.p.m. DPA dip, used with alcohol to dissolve the DPA, controlled scald but caused 6 percent injury, which appeared as scattered pitting from crystal burning. It was more extensive where liquid was trapped in stem or calyx cavities. A 2,000-p.p.m. wettable-powder formulation used as a dip treatment in 1960-61 caused no injury (table 23).

Stop-Scald was evaluated in two seasons. A Stop-Scald dip at 937 or 1,800 p.p.m. for 5 to 10 seconds controlled scald very well on Grimes Golden apples (table 23, fig. 14). Some 1-year-old commercial Stop-Scald used as a dip at 1,800 p.p.m. controlled scald, indicating that deterioration of the material is not rapid.

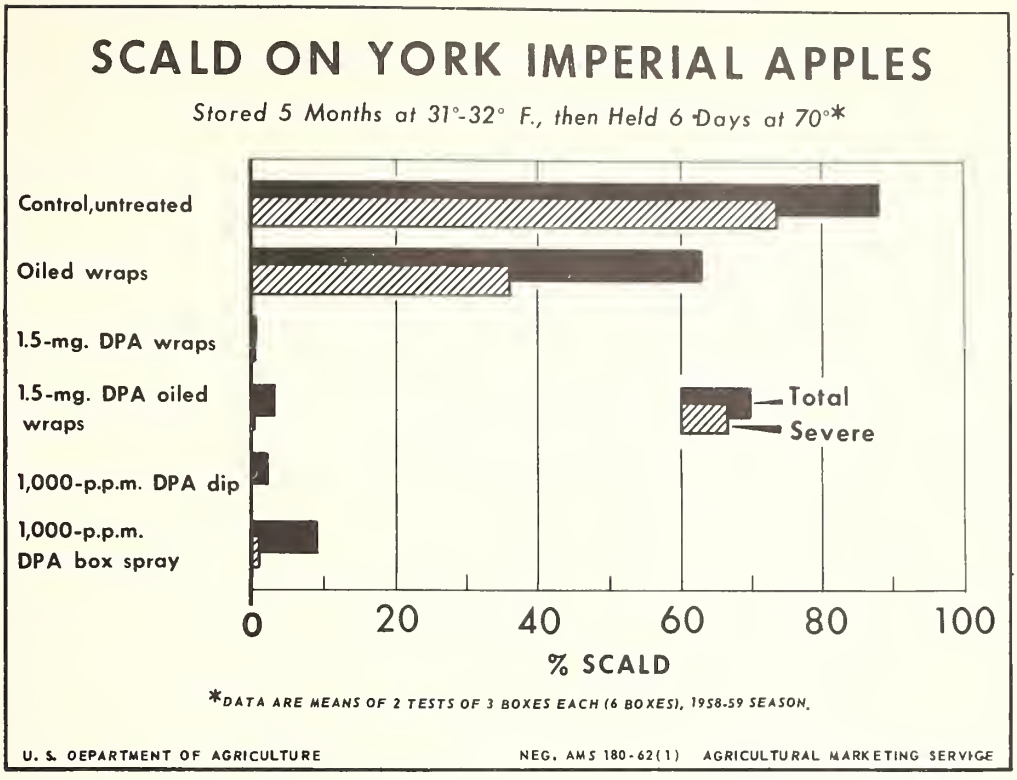

Figure 12

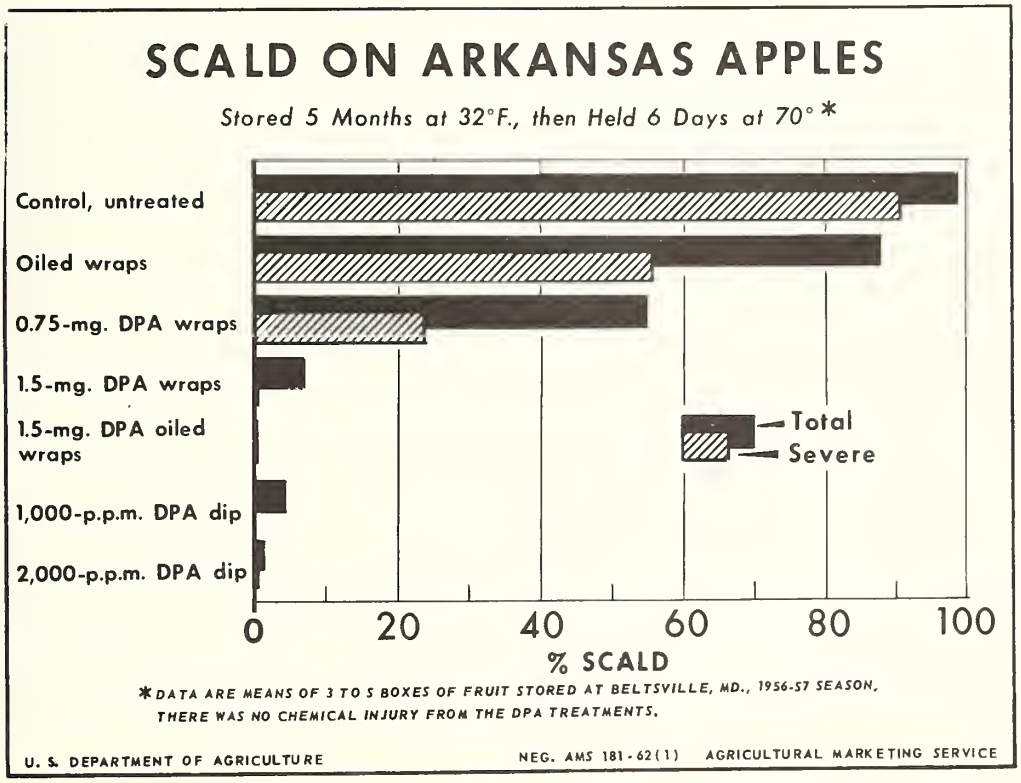

Figure 13

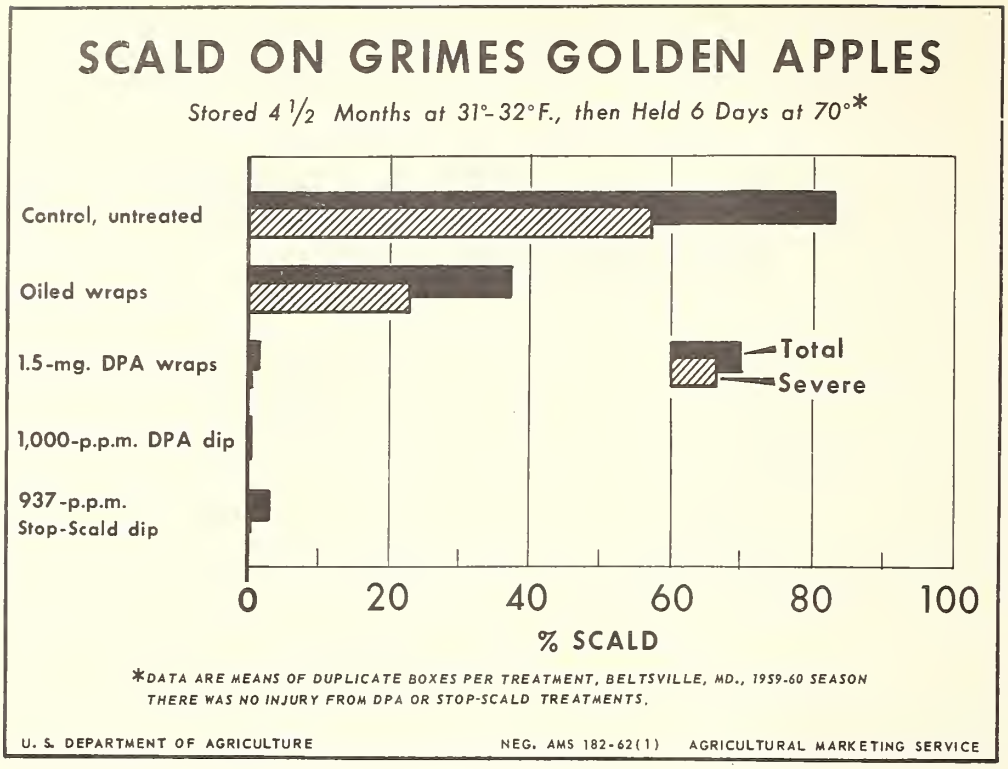

Figure 14

Grimes Golden apples were treated with Stop-Scald in one test after 8 weeks in storage (table 8). The Stop-Scald markedly reduced scald even with this delay in application. Such delayed treatment with scald inhibitors would not be recommended. Delayed treatment was less effective in controlling scald on some varieties than treatment immediately after harvest.

Cortland Apples

Figure 15 summarizes two tests with Cortland apples stored 6 months at 31° F., and then held 6 days at 70°. Oiled wraps were of little value in controlling scald. They reduced the intensity of the scald somewhat, but all the apples scalded (fig. 16).

The 1.5-mg. DPA wraps and the 1.5-mg. DPA oiled wraps controlled scald much better than did oiled wraps. The DPA oiled wrap was the better of the two types for Cortland apples.

Scald was controlled best by a brief dip in 1,000- or 1,500-p.p.m. DPA. A 500-p.p.m. DPA dip, while better than oiled wraps, was much less effective than 1,000-p.p.m. DPA. No injury was observed on Cortland apples from use of DPA. DPA did not increase decay or hasten loss of firmness.

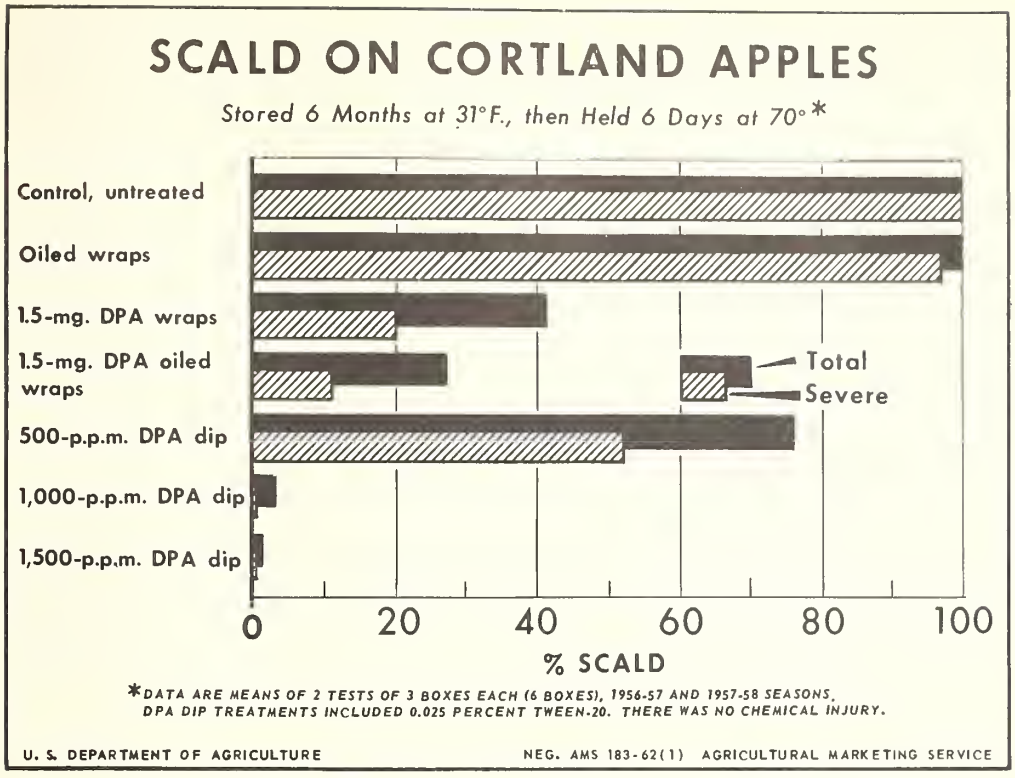

Figure 15

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Figure 16. --Nonwrapped Cortland apples scalded severely (top), oiled wraps reduced scald (center), while 1.5-mg. DPA wraps practically eliminated scald (bottom).

Golden Delicious Apples

Scald is seldom a problem during commercial storage of Golden Delicious apples. However, sometimes, when polyethylene box liners are used to prevent fruit shriveling, some scald may develop. Scald is often more extensive with perforated or folded-top liners than with sealed film liners.

Chemical scald inhibitors were evaluated in three tests with Golden Delicious apples stored 5 to 6 1/2 months at 31° to 32° F. Scald developed in only one of these (table 24). Most scald (25 percent) developed on fruit in perforated polyethylene liners; the least (none) on fruit dipped in 2,000-p.p.m. DPA. Although scald was controlled with the DPA dip, all the fruit was injured. This injury appeared as a light browning or russetting of the skin over the entire surface. This was a different type of DPA burn than that seen on other varieties. When a wettable-powder formulation of DPA at 1,500 p.p.m. was used, there was none of this skin burning on Golden Delicious fruit.

Individual wraps containing 1.5 mg. of DPA provided better scald control than oiled wraps. They caused no injury such as was found with alcohol solution of DPA.

Stop-Scald was included in two tests with Golden Delicious apples, but none of the fruit scalded. Stop-Scald caused no chemical injury on this variety and did not hasten loss of firmness during storage.

Jonathan Apples

Jonathan apples were tested in two seasons with DPA wraps and DPA dips. However, the fruit did not scald. Jonathan apples were not injured by 1.5-mg. DPA wraps or by dipping in 1,000-p.p.m. DPA.

Coverage With Scald Inhibitors

The degree of scald control obtained with chemical scald inhibitors is closely related to chemical coverage of the fruit at time of treatment. With poor coverage, scald control can be poor. Many factors affect coverage when a material is applied as a dip or spray. Varieties have different skin textures which cause variation in chemical coverage. Fruit maturity, fruit temperature, chemical concentration, length of treatment, temperature of treating solution, and wetting agents, all can affect degree of coverage.

Interest in coverage with scald-inhibiting chemicals was accelerated in 1960 when it was learned that Stop-Scald fluoresces under ultraviolet light. This principle was used to test coverage with Stop-Scald on several varieties of apples, using a long-wave ultraviolet light and examining the apples in the dark (fig. 17). When scald control was good on fruit dipped in Stop-Scald after harvest, the fruit still had a good fluorescent coating on examination after 5 to 8 months in storage. When scald control was poor, the fluorescent coating of Stop-Scald often was poor. Of the varieties tested, western-grown Winesap apples most readily took on a good coating of Stop-Scald. Grimes Golden and Red Delicious took on a relatively poor coating.

Table 25 shows the coverage obtained on four varieties with Stop-Scald, using 5-second and 30-second dips. Fruit dipped 30 seconds had a much heavier coating of the fluorescent chemical than fruit dipped only 5 seconds (fig. 18). Use of the wetting agent Tween-20 or the spreader-sticker Plyac did not improve Stop-Scald coverage. With other lots of apples or with water from other areas, these adjuvants might improve coverage.

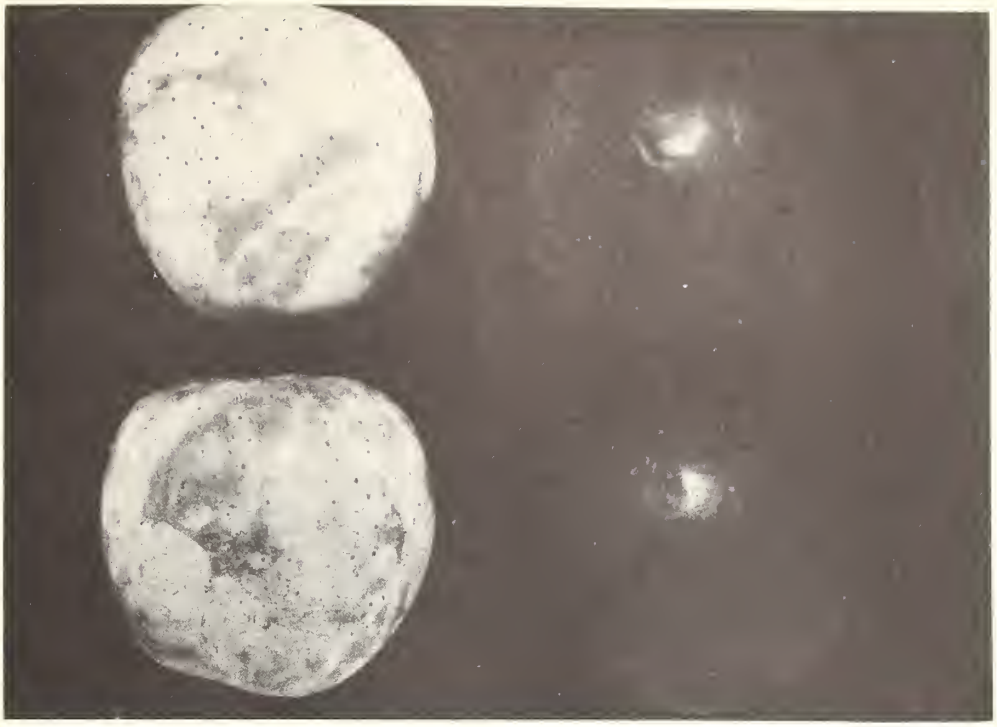

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Figure 17. --Extent of coverage with Stop-Scald can be determined by examining for fluorescence under ultraviolet light in the dark; treated left, untreated right.

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Figure 18. --Lengthening treatment time can improve coverage with Stop-Scald as indicated by fluorescence: A, untreated Grimes Golden apples; B, dipped 5 seconds, C, dipped 30 seconds, in 1,800-p.p.m. Stop-Scald.

The effects of Stop-Scald emulsion temperature and fruit temperature on coverage are shown in table 26. Warm fruit (70° F.) of the Red Delicious and Grimes Golden varieties took on a slightly better coverage of the scald inhibitor than cool fruit (40°). Winesap apples took on a good coating whether fruit was warm or cool. Increasing the temperature of treating emulsions from 40° up to 100° or 120° usually greatly improved coverage on fruit, as indicated by fluorescence. Increasing the temperature of treating emulsions from 40° to 60° or even to 80° did not always improve coverage if coverage was fairly good with the lower temperature. But when the treating emulsion was 100° or 120°, coverage was always better than with 40° or 60° emulsions (fig. 19). These findings on Stop-Scald coverage are in general agreement with those of Mattus (14).

Figure 20 shows that doubling the concentration of a Stop-Scald treatment from 1,800 p.p.m. to 3,600 p.p.m. increased coverage at both low (60° F.) and high (120° F.) emulsion temperatures. This is as expected; the fluorescent technique of examining apples provided only a visual way of checking it (fig. 21).

Increasing coverage with Stop-Scald beyond that needed for scald control is unnecessary, and a light all-over fluorescent coating is probably adequate. If Stop-Scald coverage is satisfactory, as indicated by examination under fluorescent light, when fruit is dipped in a 60° F. emulsion, then there is no need to increase coverage with a higher temperature emulsion, a higher concentration, or with wetting agents. Too heavy a coating may leave residues in excess of the allowed tolerance of 3 p.p.m.

BN-15565

Figure 19.--Increasing temperature of Stop-Scald emulsions can improve coverage as indicated by fluorescence: A, untreated Red Delicious apples; B, dipped in 60° F. emulsion; C, dipped in 120° F. emulsion. Treatment was for 5 seconds in 1,800-p.p.m. Stop-Scald.

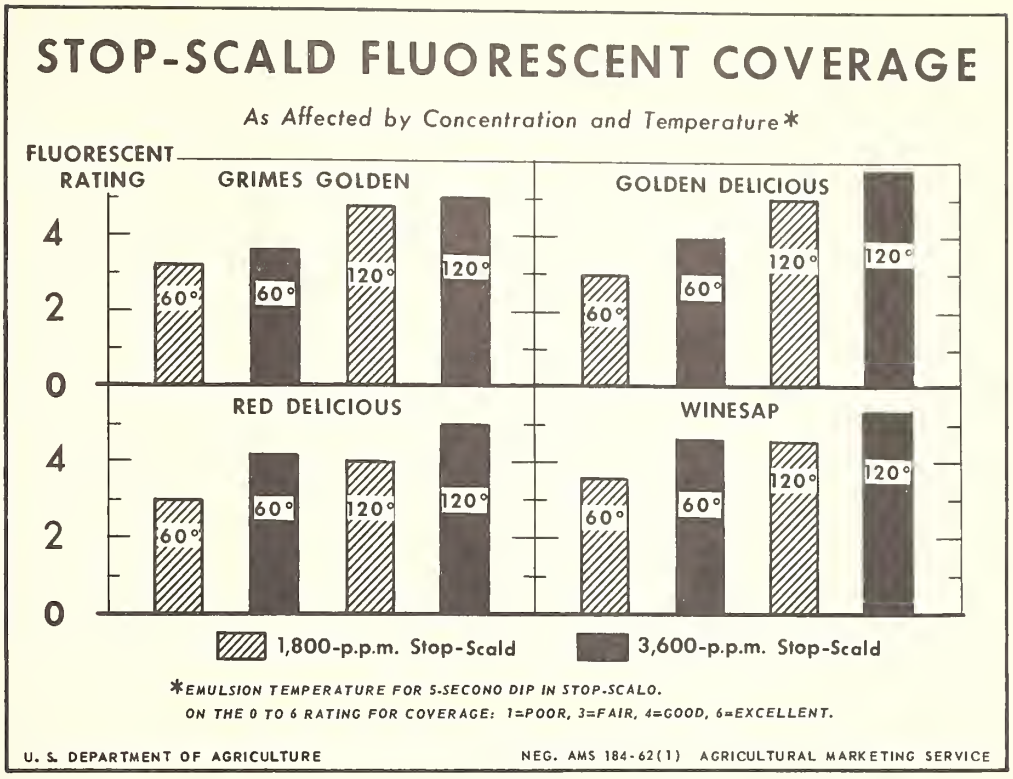

Figure 20

BN-15566

Figure 21.--Higher concentrations of Stop-Scald can increase coverage as indicated by fluorescence: A, untreated Grimes Golden apples; B, dipped in 1,800-p.p.m. Stop-Scald, C, dipped in 3,600-p.p.m. Stop-Scald, for 5 seconds.

Conversely, if fluorescence tests show that fruit has poor or spotty coverage, procedures to improve coverage should be attempted. Mattus (14) reported that poor coverage (poor fluorescence) results in about 1/2-p.p.m. residue. Fair to good Stop-Scald coverage is equivalent to about 1.5 to 2.5-p.p.m. residue, which gives fair to good fluorescence.

Senescence Inhibitors

A senescence inhibitor, N6-benzyladenine, recently has been widely tested on leafy green vegetables. It has shown a beneficial effect in retarding loss of green color in head lettuce, brussels sprouts, and some other vegetables.

Eight apple varieties, Stayman, Turley, Grimes Golden, Yellow Newtown, McIntosh, Rome Beauty, York Imperial, and Jonathan, were treated with N6-benzyladenine soon after harvest to determine the effect on ripening, color, and storage scald. Concentrations of 10 and 20 p.p.m. of the material with 0.05-percent Tween-20 were tested as 5-second dips. After treatment, the apples were stored from October 2, 1960, to March 7, 1961, at 32° F., then held 7 days at room temperature.

Color, firmness, decay, and extent of scald were similar in both treated and untreated apples, either on removal from storage or after 7 days at room temperature. The senescence inhibitor caused no injury to apples but did not retard ripening or scald in the concentrations tested.

CONCLUSIONS

Both diphenylamine (DPA) and ethoxyquin (Stop-Scald) provided better control of storage scald than oiled wraps. DPA gave the most scald control, sometimes 100 percent, and was appreciably better than Stop-Scald in numerous tests. In a severe scald year such as 1959-60, scald control with these chemical inhibitors was poorer.

Dipping fruit for a few seconds in a tank containing DPA or Stop-Scald was the most satisfactory method of getting good coverage, necessary for scald control. A drip-type brush applicator, tested on Red Delicious and Stayman apples, also gave good control. Spraying or drenching filled field boxes or loose fruit on rollers also was effective.

Two types of DPA-treated wraps, 1.5-mg. DPA wraps and 1.5-mg. DPA oiled wraps, were strikingly superior to oiled wraps without DPA for scald control. Sometimes the DPA wraps controlled scald nearly as well as dipping in DPA or Stop-Scald. DPA wraps containing mineral oil were slightly better than plain DPA wraps for most varieties. One-year-old DPA wraps had lost most of their effectiveness.

Sprays applied 1 day before harvest with 2,000-p.p.m. DPA or 2,800-p.p.m. Stop-Scald gave poor protection from scald. Results with preharvest sprays were sometimes better than with oiled wraps, but were markedly inferior to postharvest dip or spray applications.

Alcohol solutions of DPA caused injury on some varieties, which was apparent after storage. This injury appeared as scattered surface pitting from crystal burn or was concentrated in stem or calyx cavities. Use of wettable-powder formulations of DPA largely eliminated chemical injury.

Stop-Scald caused no injury when used as a postharvest treatment, but preharvest sprays often left small brown residue spots on the lower sides of apples. Neither DPA nor Stop-Scald hastened loss of firmness, impaired flavor, or was otherwise detrimental to the storage life of apples.

Chemical dip treatments were most effective for scald control if applied within a few days of harvest. However, when apples were treated after 1 or 2 weeks in storage, scald control usually was still good. When apples were stored 4 weeks before treatment, scald control was much poorer.

Brushing or wiping treated apples while still wet or after drying for about an hour reduced scald control in a severe scald year, indicating some of the chemical was removed. In other tests (lighter scald years), fruit could be brushed or wiped soon after treatment without loss of scald control. Red Delicious apples dipped in DPA or Stop-Scald could be brushed after 2 weeks or washed after 4 weeks without losing scald control.

Good coverage with Stop-Scald was necessary for effective scald control. Coverage was improved, as indicated by fluorescence under ultraviolet light, by lengthening the time in the treating tank, increasing the emulsion concentration, and raising the emulsion temperature to 80°, 100°, or 120° F. Coverage also was better on warm fruit than on cool fruit.

Use of chemical inhibitors is recommended for varieties likely to scald, if storage for several months is planned. Stop-Scald was tested on Red Delicious, Rome Beauty, Stayman, York Imperial, and Grimes Golden, and is recommended as a brief postharvest dip or spray treatment at about 1,800 p.p.m. (2 pints per 100 gallons of a 70 percent emulsion). The price per bushel for treatment is small compared with the possible savings from reduced losses due to scald.

DPA recently was cleared for use on apples as a preharvest spray or in impregnated tissue wraps for postharvest use. Very good scald control is possible with 1.5-mg. DPA oiled wraps. Preharvest tree sprays with 2,000-p.p.m. DPA showed some promise for scald control but were appreciably less effective than postharvest treatments.

The use of DPA as a postharvest dip or spray treatment for apple scald control has not been approved. Such clearance is still being sought. If clearance for postharvest use of DPA as a dip, spray, or with a brush applicator is approved, its commercial use should provide excellent protection from scald. A concentration of 1,000 p.p.m. of DPA provided good scald protection of Grimes Golden, York Imperial, and Cortland varieties. A concentration of 2,000 p.p.m. of DPA was better for Red Delicious, Rome Beauty, Stayman, and Arkansas varieties. For late-picked fruit or fruit less likely to scald, of these latter four varieties, treatment with 1,000 p.p.m. of DPA should be adequate.

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TABLE 1.--Effect of various treatments on scald, decay, and firmness of Red Delicious apples stored 6 months at 31° to 32° F., then held 6 days at 70°[1]

Prestorage treatment[2]	Scald		Decay	Firmness
	Severe	Total		
	Percent	Percent	Percent	Pounds
Control, untreated	4	36	5	11.5
Oiled wraps	5	44	1	11.6
1.5-mg. DPA wraps	1	13	3	11.0
1.5-mg. DPA oiled wraps	0	6	2	10.6
1,000-p.p.m. DPA dip	0	9	2	11.5
2,000-p.p.m. DPA dip	0	2	2	11.2
2,000-p.p.m. DPA box spray	0	2	2	11.1
937-p.p.m. Stop-Scald dip	7	41	2	12.0
1,875-p.p.m. Stop-Scald dip	2	18	2	10.9
Orchard control[3]	17	89	2	12.2
2,000-p.p.m. DPA tree spray	7	54	1	11.9
1,875-p.p.m. Stop-Scald tree spray	14	65	0	11.9
2,811-p.p.m. Stop-Scald tree spray	24	81	1	12.2

[1] Values are means of triplicate boxes stored at Charles Town, W. Va., 1959-60 season. Fruit picked Sept. 22, treated and stored Sept. 23, 1959; initial firmness 15.1 pounds.

[2] Tree sprays were applied 1 day before harvest. There was no injury from any DPA or Stop-Scald treatment. All DPA dip and spray treatments included 0.05 percent of Tween-20.

[3] The orchard control fruit was from the same trees to which tree sprays were applied, but from another sector of each tree.

TABLE 2.--Effect of various treatments on scald, decay, and firmness of Red Delicious apples stored 6 months at 31° to 32°F., then held 6 days at 70°[1]

Prestorage treatment[2]	Scald		Decay	Firmness
	Severe	Total		
	Percent	Percent	Percent	Pounds
Control, untreated	15	70	2	12.6
Oiled wraps	12	64	2	12.8
1.5-mg. DPA wraps	10	70	0	12.2
1.5-mg. DPA oiled wraps	17	68	2	12.5
1,000-p.p.m. DPA dip	12	53	1	12.4
2,000-p.p.m. DPA dip	1	18	1	11.9
2,000-p.p.m. DPA box spray	3	27	2	--
2,000-p.p.m. DPA tree spray	5	38	3	12.2
937-p.p.m. Stop-Scald dip	35	89	1	12.6
1,875-p.p.m. Stop-Scald dip	25	79	0	12.8
1,875-p.p.m. Stop-Scald tree spray	11	81	3	--
2,811-p.p.m. Stop-Scald tree spray	19	65	3	11.6
Sealed polyethylene liner[3]	38	84	3	11.6
Store 1 wk., then 1,000-p.p.m. DPA dip	7	56	0	--
Store 2 wks., then 1,000-p.p.m. DPA dip	11	58	2	--
Store 4 wks., then 1,000-p.p.m. DPA dip	12	67	3	--
Store 1 wk., then 1.5-mg. DPA wraps	12	64	1	--
Store 2 wks., then 1.5-mg. DPA wraps	19	67	1	--
Store 4 wks., then 1.5-mg. DPA wraps	18	78	2	--

[1] Values are means of triplicate boxes stored at Beltsville, Md., 1959-60 season. Fruit picked Sept. 18, treated and stored Sept. 19, 1959; initial firmness 15.4 pounds.

[2] Tree sprays were applied 1 day before harvest. There was no injury from any DPA or Stop-Scald treatment, but a few DPA crystals showed in the calyx of dipped fruit after storage. All DPA dip and spray treatments included 0.05 percent of Tween 20.

[3] Atmosphere in sealed poly liners averaged 3 percent CO_2 and 17 percent O_2 on removal from storage. All liners used were made of 1.5-mil polyethylene (low density).

TABLE 3.--Effect of various treatments on scald, chemical injury, and firmness of Red Delicious apples stored 5 1/2 months at 31° to 32° F., then held 6 days at room temperature[1]

Prestorage treatment[2]	Scald		Chemical injury	Firmness
	Severe	Total		
	Percent	Percent	Percent	Pounds
Control, untreated	8	28	--	13.7
Oiled wraps	29	67	--	14.5
1.5-mg. DPA wraps	16	55	0	14.5
1.5-mg. DPA oiled wraps	1	14	0	14.2
1,000-p.p.m. DPA dip	1	11	0	14.3
2,000-p.p.m. DPA dip	0	1	9	13.2
2,000-p.p.m. DPA dip & Plyac	0	2	1	14.2
2,000-p.p.m. DPA box spray	0	2	0	--
2,000-p.p.m. 42% DPA dip & Plyac	0	5	0	14.7
1,800-p.p.m. Stop-Scald dip	5	29	0	14.8
1,800-p.p.m. Stop-Scald box spray	1	13	0	--
3,600-p.p.m. Stop-Scald dip	9	40	0	15.2
2,000-p.p.m. 80% Stop-Scald dip	7	36	0	13.9
3,000-p.p.m. DDU dip[3]	9	34	1	15.0
Sealed poly liner	3	24	--	13.8
Store 2 wks., then 2,000-p.p.m. DPA dip	1	11	0	--
Store 2 wks., then 2,000-p.p.m. 42% DPA dip & Plyac	2	18	0	--
Store 2 wks., then 1,800-p.p.m. Stop-Scald dip	1	15	0	--
Store 2 wks., then 2,000-p.p.m. 80% Stop-Scald dip	1	7	0	--
2,000-p.p.m. ascorbic acid dip	9	38	0	--
2,000-p.p.m. tannic acid dip	9	20	0	--
2,000-p.p.m. pyrogallic acid dip	3	15	73	--
2,000-p.p.m. succinic acid dip	6	19	0	--
2,000-p.p.m. thiodipropionic acid dip	9	40	0	--

[1] Values are means of triplicate boxes stored at Beltsville, Md., 1960-61 season. Fruit picked Sept. 22, treated and stored Sept. 23, 1960; initial firmness 15.3 pounds.

[2] All DPA treatments included 0.05 percent of Tween-20, except where the spreader-sticker Plyac was used. Plyac was used at a rate of 1 pint per 100 gallons. Forty-two percent DPA is a wettable-powder formulation.

[3] DDU is dimethyl-diphenyl-urea.

TABLE 4.--Effect of various treatments on scald, chemical injury, and firmness of Red Delicious apples stored 6 months at 32° F., then held 6 days at room temperature[1]

Prestorage treatment	Scald		Chemical injury	Firmness[1]
	Severe	Total		
	Percent	Percent	Percent	Pounds
Control, untreated	10	19	--	12.4
Oiled wraps	4	7	--	12.8
1.5-mg. DPA wraps	0	0	0	12.6
1.5-mg. DPA oiled wraps	0	1	0	12.9
2,000-p.p.m. DPA dip + Plyac	0	0	0	13.1
1,000-p.p.m. 42% DPA dip	1	1	0	--
2,000-p.p.m. 42% DPA dip	0	0	0	12.5
2,000-p.p.m. 42% DPA dip + Plyac	0	0	0	--
2,000-p.p.m. 42% DPA dip + Plyac brushed while still wet	0	0	0	--
1,800-p.p.m. 70% Stop-Scald dip	0	1	0	12.5
3,600-p.p.m. 70% Stop-Scald dip	1	2	0	12.7
2,000-p.p.m. 80% Stop-Scald dip	1	2	0	12.6
1,800-p.p.m. 70% Stop-Scald dip brushed while still wet[2]	0	1	0	--

[1] Values are means of duplicate boxes of composited fruit stored at Charles Town, W. Va., 1960-61 season. Picked Sept. 28, treated and stored Sept. 29; initial firmness 15.9 pounds. Forty-two percent DPA is a wettable-powder formulation.

[2] These apples still had a good fluorescent coating of Stop-Scald in March.

TABLE 5.--Effect of various treatments on scald on 5 strains of Red Delicious apples stored 8 months at 31° to 32° F., then held 6 days at room temperature, Greencastle, Pa., 1960-61 season

Postharvest treatment[1]	Total scald[2]					
	Standard Delicious	Richared	Starking	Red King	Royal Red	Mean 5 tests
	Percent	Percent	Percent	Percent	Percent	Percent
Control, immediate storage	66	45	30	29	48	44
Control, on straw 7 days before storage	63	29	20	15	30	31
Dip Stop-Scald, immediate storage	58	18	10	22	10	24
Dip DPA, immediate storage	16	9	8	4	8	9
Brush, then Stop-Scald dip	36	50	4	10	10	22
Brush, then DPA dip	12	18	0	2	6	8
Wash, then Stop-Scald dip	22	4	8	28	10	14
Wash, then DPA dip	0	6	2	8	48	13
Wash, then brush on Stop-Scald[3]	18	14	4	25	6	13
Wash, then brush on DPA[3]	4	6	0	0	4	3
Dip Stop-Scald, dry, then brush	38	30	36	16	16	27
Dip DPA, dry, then brush	0	12	2	10	38	12
Spray on Stop-Scald, dry, then brush	36	20	16	20	20	22
Spray on DPA, dry, then brush	18	24	8	18	18	17
Straw 7 days, then Stop-Scald dip[4]	10	12	11	8	0	8
Straw 7 days, then DPA dip[4]	4	6	0	4	0	3
Dip Stop-Scald, brush after 2 wks	8	20	32	16	8	17
Dip DPA, brush after 2 wks	8	4	8	2	24	9
Dip Stop-Scald, brush after 4 wks	60	14	7	22	10	23
Dip DPA, brush after 4 wks	12	6	0	2	2	4
Dip Stop-Scald, wash after 4 wks	10	22	10	10	10	12
Dip DPA, wash after 4 wks	10	12	8	2	4	7
Store 2 wks, brush, then Stop-Scald dip	0	2	4	6	2	3
Store 2 wks, brush, then DPA dip	0	0	0	0	0	0
Store 4 wks, brush, then Stop-Scald dip	44	34	11	12	24	25
Store 4 wks, brush, then DPA dip	6	12	12	14	16	12

[1] Stop-Scald used at 1,800 p.p.m.; DPA was 42-percent wettable powder used at 2,000 p.p.m. with Plyac as a spreader-sticker at 1 pint/100 gallons.

[2] Most of the scald was classified as slight. There was no injury from Stop-Scald or DPA treatments. In this test, half of the apples were packed with oiled wraps and half were naked. Results are combined for presentation.

[3] Applied with a commercial drip-type brush applicator.

[4] After harvest these apples were placed on straw under the trees for 7 days to develop red color before treatment with Stop-Scald or DPA.

TABLE 6.--Effect of various preharvest sprays on scald of Red Delicious and Rome Beauty apples stored at 31° to 32° F., then held 6 days at 70° at Beltsville, Md.[1]

Variety and spray treatment	Scald	
	Severe	Total
	Percent	Percent
Red Delicious (stored 5 months):[2]		
Control, no spray	2	29
2,000-p.p.m. DPA spray + Plyac	20	38
2,000-p.p.m. 42% W.P. DPA spray	1	19
2,700-p.p.m. 70% Stop-Scald spray	29	46
3,000-p.p.m. 80% Stop-Scald spray	20	33
Rome Beauty (stored 5 1/2 months):[3]		
Control, no spray	82	93
2,000-p.p.m. DPA spray + Plyac	38	71
2,000-p.p.m. W.P. DPA spray	36	52
2,700-p.p.m. 70% Stop-Scald spray	52	90
3,000-p.p.m. 80% Stop-Scald spray	34	83
Rome Beauty (stored 6 1/2 months):[4]		
Control, no spray	91	98
2,000-p.p.m. DPA spray, pick in 1 hr	66	89
2,000-p.p.m. DPA spray, pick in 24 hrs	71	89
2,811-p.p.m. 70% Stop-Scald spray, pick in 1 hr	68	92
2,811-p.p.m. 70% Stop-Scald spray, pick in 24 hrs	84	98

[1] Values based on duplicate boxes from two trees of each treatment. There was no chemical injury from any of the sprays, but Stop-Scald apples show some residue marks.

[2] Sprayed Sept. 28, picked Sept. 30, 1960 (light rain before harvest). Coverage with Stop-Scald was poor as indicated by fluorescence in March.

[3] Sprayed at 10 a.m. Oct. 5, picked at 3 p.m. the same day.

[4] Sprayed Oct. 8, picked Oct. 9, 1959 (shower during 24-hour period).

TABLE 7.--Effect of various DPA and Stop-Scald dip treatments on scald and chemical injury of 5 varieties of apples stored at 31° to 32° F.

Variety and dip treatment[1]	Scald		Chemical injury[2]
	Severe	Total	
	Percent	Percent	Percent
Red Delicious (examined March 7, 1961):			
Control, untreated	32	65	--
2,000-p.p.m. DPA (alcohol emulsion)	1	5	58
2,000-p.p.m. 42% W. P. DPA formulation	1	21	0
2,000-p.p.m. 50% liquid DPA formulation	7	38	0
1,800-p.p.m. 70% Stop-Scald	3	21	0
2,000-p.p.m. 80% Stop-Scald	4	16	0
Rome Beauty (examined March 25, 1961):			
Control, untreated	62	87	--
2,000-p.p.m. DPA (alcohol emulsion)	0	1	44
2,000-p.p.m. 42% W. P. DPA formulation	17	57	0
2,000-p.p.m. 50% liquid DPA formulation	25	56	0
1,800-p.p.m. 70% Stop-Scald	18	51	0
2,000-p.p.m. 80% Stop-Scald	3	20	0
Red Rome (examined March 26, 1961):			
Control, untreated	70	93	--
2,000-p.p.m. DPA (alcohol emulsion)	0	2	38
2,000-p.p.m. 42% W. P. DPA formulation	23	44	6
2,000-p.p.m. 50% liquid DPA formulation	17	48	0
1,800-p.p.m. 70% Stop-Scald	23	53	0
2,000-p.p.m. 80% Stop-Scald	10	30	0
Stayman (examined March 27, 1961):			
Control, untreated	5	39	--
2,000-p.p.m. (alcohol emulsion)	0	0	1
2,000-p.p.m. 42% W. P. DPA formulation	0	0	0
2,000-p.p.m. 50% liquid DPA formulation	0	2	0
1,800-p.p.m. 70% Stop-Scald	0	4	0
York (examined April 17, 1961):			
Control, untreated	4	13	--
2,000-p.p.m. DPA (alcohol emulsion)	0	1	5
2,000-p.p.m. 42% W. P. DPA formulation	0	0	0
2,000-p.p.m. 50% liquid DPA formulation	0	1	0
1,800-p.p.m. 70% Stop-Scald	0	0	0
2,000-p.p.m. 80% Stop-Scald	0	2	0

[1] All treatments (100 apples per treatment) were used with Plyac as a spreader-sticker at the rate of 1 pint per 100 gallons. The control apples were dipped in water with Plyac. Treated Oct. 26-31, 1960, with 10-15-second dip.

[2] Crystal burn mostly in stem or calyx cavity.

TABLE 8.--Effect of delayed application of Stop-Scald used with and without Tween-20 on scald control of 3 apple varieties[1]

Variety and treatment	Scald	
	Severe	Total
	Percent	Percent
Red Delicious (7-week delay):		
Control, untreated	32	65
1,875-p.p.m. Stop-Scald dip	12	42
1,875-p.p.m. Stop-Scald + 0.1% Tween-20	7	43
Rome Beauty (4-week delay):		
Control, untreated	62	87
1,875-p.p.m. Stop-Scald dip	17	66
1,875-p.p.m. Stop-Scald + 0.1% Tween-20	2	46
Grimes Golden (8-week delay):		
Control, untreated	26	74
1,875-p.p.m. Stop-Scald dip	2	23
1,875-p.p.m. Stop-Scald + 0.1% Tween-20	6	40

[1] Data based on one box per treatment stored at Beltsville, Md., 1960-61 season. Apples were stored at 31° to 32° F. before and after treatment. Treated Nov. 14, 1960. Red Delicious examined March 1, Rome Beauty March 17, and Grimes Golden Jan. 27, all in 1961.

TABLE 9.--Effect of wetting agents used with DPA for scald control on Red Delicious apples, stored 5 months at 31° to 32° F., then held 6 days at 70°

Prestorage treatment	Scald[1]		Chemical injury
	Severe	Total	
	Percent	Percent	Percent
Control, untreated	43	83	--
2,000-p.p.m. DPA dip	8	43	[2] 4
2,000-p.p.m. DPA dip plus .05% Tween-20	25	61	1
2,000-p.p.m. DPA dip plus .1% Tween-20	20	56	2
2,000-p.p.m. DPA dip plus .1% Tween-20 and colloidal spray modifier[3]	31	57	1

[1] Values based on duplicate boxes, Beltsville, Md., 1959-60 season.
[2] Many other fruit show clusters of white crystals, but only 4 percent show skin burning.
[3] Used at rate of 1 quart/100 gallons.

TABLE 10.--Effect of various treatments on scald of Rome Beauty apples stored 5 months at 32° F., then held 6 days at room temperature[1]

Prestorage treatment	Scald		Chemical injury
	Severe	Total	
	Percent	Percent	Percent
Control, untreated	95	99	--
Oiled wraps	86	97	0
0.75-mg. DPA wraps	85	98	0
1.5-mg. DPA wraps	35	69	0
1.5-mg. DPA oiled wraps	16	56	0
2.0-mg. DPA wraps	33	78	0
1,000-p.p.m. DPA dip	28	80	0
2,000-p.p.m. DPA dip	0	5	9
3,000-p.p.m. DPA dip	0	4	7

[1] Fruit picked Oct. 2, treated and stored Oct. 4, 1956, Beltsville, Md. Alcohol emulsions of DPA included 0.05 percent of Tween-20. Individual values are means of 3 to 6 boxes of fruit.

TABLE 11.--Effect of various treatments on scald, Jonathan spot, and firmness of Red Rome apples stored 5 months at 32° F., then held 6 days at 60°

Prestorage treatment[1]	Scald		Jonathan spot	Firmness
	Severe	Total		
	Percent	Percent	Percent	Pounds
Control, untreated	9	25	25	--
Oiled wraps	4	8	20	11.7
1.5-mg. DPA wraps	0	1	19	11.5
1,000-p.p.m. DPA dip	0	0	25	--
Sealed poly liner + oiled wraps	0	6	0	11.5
Sealed poly liner + DPA wraps	0	0	0	--

[1] Values are means of 300 apples picked and stored Oct. 23, 1957, at Charles Town, W. Va. Polyethylene liners were 1.5-mil thickness. Atmosphere in film liners on removal from cold storage averaged 5 percent CO_2 and 10 percent O_2.

TABLE 12.--Effect of various treatments on scald, firmness, and Jonathan spot of Rome Beauty apples stored 6 months at 31°F. in boxes with various types of liners and then held 6 days at 70°[1]

Type of box liner and prestorage treatment	Scald		Chemical injury	Firmness	Jonathan spot
	Severe	Total			
	Percent	Percent	Percent	Percent	Percent
Paperboard liner:					
Untreated, control	48	79	--	12.1	5
Oiled wraps	12	46	0	12.4	9
1.5-mg. DPA wraps	7	26	1	12.1	6
2,000-p.p.m. DPA dip	0	0	20	11.6	9
1.5-mg. DPA oiled wraps	2	7	0	11.3	6
2.0-mg. DPA wraps	1	5	0	11.8	8
2.0-mg. DPA wraps (2-week delay)	2	14	0	12.1	5
Perforated polyethylene:[2]					
Untreated, control	57	87	--	12.4	1
Oiled wraps	5	36	0	12.2	0
1.5-mg. DPA wraps	2	17	0	11.6	0
2,000-p.p.m. DPA dip	0	0	5	11.7	0
Sealed polyethylene:					
Untreated, control	15	44	--	13.7	0
Oiled wraps	1	20	0	13.4	0
1.5-mg. DPA wraps	1	11	0	13.5	0
2,000-p.p.m. DPA dip	0	0	1	13.7	0

[1] Values are means of 4 tests (14 boxes), 2 in 1956-57, and 2 in 1957-58. Fruit picked Oct. 8 and 18, 1956, and Oct. 9 and 21, 1957; liners removed during the holding period at 70°. DPA dip included 0.025 percent of Tween-20.

[2] Perforated with four 1/8-inch holes. All film liners were 1.5-mil film.

TABLE 13.--Effect of various treatments on scald, chemical injury, and firmness of Rome Beauty apples stored 6 months at 31° to 32° F., then held 6 days at 70°[1]

Prestorage treatment	Scald		Chemical injury	Firmness
	Severe	Total		
	Percent	Percent	Percent	Pounds
Control, untreated	78	96	--	11.7
Oiled wraps	66	89	0	12.3
1.5-mg. DPA wraps	41	83	0	12.0
1.5-mg. DPA oiled wraps	38	74	0	12.8
1.5-mg. DPA oiled wraps (yr. old)	42	81	0	--
1,000-p.p.m. DPA dip	44	78	0	12.6
2,000-p.p.m. DPA dip	7	37	2	12.7
2,000-p.p.m. DPA dip, wiped[2]	38	77	0	--
2,000-p.p.m. DPA dip with Plyac	0	9	16	--
Plyac dip, 1 pt./100 gal	74	95	0	--
937-p.p.m. Stop-Scald dip	60	88	0	12.3
1,875-p.p.m. Stop-Scald dip	47	83	0	12.3
2,811-p.p.m. Stop-Scald dip	32	80	0	11.9
1,875-p.p.m. Stop-Scald dip, wiped[2]	56	91	0	--
Sealed poly liner[3]	22	46	--	11.4
3,000-p.p.m. DDU dip[4]	80	96	0	11.2
3,000-p.p.m. DDU dip, wiped[2]	64	86	0	--
Stored 1 month, then 2,000-p.p.m. DPA dip[5]	29	74	2	11.1
Stored 1 month, then 1,875-p.p.m. Stop-Scald dip[5]	54	90	0	11.7
Stored 1 month, then 3,000-p.p.m. DDU dip[5]	80	98	0	11.4

[1] Values are means of triplicate boxes picked Oct. 16, treated and stored Oct. 27, 1959, at Beltsville, Md. Initial firmness was 17.5 pounds. All DPA dip treatments included 0.05 percent of Tween-20.

[2] Apples wiped with towel after 1 hour.

[3] Sealed poly liners averaged 7 percent CO_2 and 7 percent O_2 on removal from storage.

[4] DDU is dimethyl-diphenyl-urea.

[5] Stored 1 month at 31° to 32° F., then treated with specified chemical and returned to storage 5 additional months.

TABLE 14.--Effect of various treatments on scald and chemical injury of Rome Beauty apples stored 5 1/2 months at 32°F., then held 6 days at room temperature[1]

Prestorage treatment	Scald		Chemical injury
	Severe	Total	
	Percent	Percent	Percent
Control, untreated	75	93	--
Oiled wraps	40	79	0
1.5-mg. DPA wraps	22	57	0
1.5-mg. DPA oiled wraps	3	11	0
1,000-p.p.m. DPA dip	30	57	0
2,000-p.p.m. DPA dip	0	3	3
2,000-p.p.m. DPA dip with Plyac	2	9	1
2,000-p.p.m. DPA box spray with Plyac	4	15	0
2,000-p.p.m. 42% DPA dip with Plyac	5	19	0
Sealed poly liner[2]	5	16	0
1,800-p.p.m. Stop-Scald dip	18	40	0
1,800-p.p.m. Stop-Scald box spray	12	56	0
3,600-p.p.m. Stop-Scald dip[3]	2	11	0
2,000-p.p.m. 80% Stop-Scald dip	9	34	0
3,000-p.p.m. DDU dip & Tween-20[4]	52	82	0
Stored 2 wks., then 2,000-p.p.m. DPA dip[5]	0	4	6
Stored 2 wks., then 2,000-p.p.m. 42% DPA dip with Plyac[5]	30	63	0
Stored 2 wks., then 1,800-p.p.m. Stop-Scald dip[5]	28	53	1
Stored 2 wks., then 2,000-p.p.m. 80% Stop-Scald dip[5]	26	54	0
2,000-p.p.m. ascorbic acid dip	67	85	0
2,000-p.p.m. tannic acid dip	71	94	0
2,000-p.p.m. pyrogallic acid dip	58	85	0
2,000-p.p.m. succinic acid dip	70	91	0
2,000-p.p.m. thiodipropionic acid dip	73	89	1
1,800-p.p.m. Stop-Scald dip & oiled wraps	8	26	0

[1] Values are means of triplicate boxes picked Oct. 12, treated and stored at Beltsville, Md., Oct. 13, 1960. Initial firmness was 17.3 pounds. All DPA dip and spray treatments included 0.05 percent of Tween-20, except where spreader-sticker Plyac was used. The 42-percent DPA is a wettable-powder formulation.

[2] Atmosphere when opened March 21 averaged 4.2% CO_2 and 11.8% O_2.

[3] Coverage as indicated by fluorescence was much better for 3,600-p.p.m. Stop-Scald than for 1,800-p.p.m.

[4] DDU is dimethyl-diphenyl-urea.

[5] Stored 2 weeks at 32°F., then treated with specified chemical and returned to storage 5 additional months.

TABLE 15.--Effect of various treatments on scald and firmness of Red Stayman apples stored 6 months at 31° to 32°F., then held 6 days at 70°[1]

Prestorage treatment	Scald		Firmness
	Severe	Total	
	Percent	Percent	Pounds
Control, untreated	20	75	10.1
Oiled wraps	8	52	9.5
1.5-mg. DPA oiled wraps	1	20	9.4
2,000-p.p.m. DPA dip	0	0	9.1
1,875-p.p.m. Stop-Scald dip	1	12	9.0
3,000-p.p.m. DDU dip[2]	4	51	9.4

[1] Data based on duplicate boxes. Fruit picked and stored at Beltsville, Md., Oct. 14, treated Oct. 26, 1959; initial firmness 16.0 pounds.
[2] DDU is dimethyl-diphenyl-urea.

TABLE 16.--Effect of various treatments on scald and firmness of Stayman apples stored 5 months at 32°F., then held 6 days at 60°

Prestorage treatment [1]	Scald		Firmness
	Severe	Total	
	Percent	Percent	Pounds
Control, untreated	7	32	--
Oiled wraps	10	30	10.6
1.5-mg. DPA wraps	0	2	10.8
1,000-p.p.m. DPA dip	0	3	--
Nonsealed poly liner + oiled wraps[2]	12	31	11.5
Sealed poly liner + oiled wraps[3]	5	13	11.6

[1] Values are means of 300 apples picked, treated, and stored in tray cartons Oct. 23, 1957, at Charles Town, W. Va. Initial firmness 17.0 pounds. Polyethylene liners were 1.5-mil thickness.
[2] Atmosphere in nonsealed liners on removal from cold storage averaged 4 percent CO_2 and 13 percent O_2.
[3] Atmosphere in sealed liners on removal from cold storage averaged 5 percent CO_2 and 6 percent O_2.

TABLE 17.--Effect of various treatments on scald and firmness of Red Stayman apples stored 6 months at 31°F., then held 7 days at room temperature[1]

Treatment	Scald		Firmness
	Severe	Total	
	Percent	Percent	Pounds
Wash and brush, control	30	79	12.4
Wash and brush, oiled wraps	4	35	13.6
Wash and brush, 1.5-mg. DPA wraps	0	5	13.0
Wash and brush, 2,000-p.p.m. DPA dip	0	1	12.9
Wash and brush, 2,000-p.p.m. 42% W. P. DPA dip	0	0	12.6
2,000-p.p.m. 42% W. P. DPA dip then brushed wet	2	17	--
2,000-p.p.m. 42% W. P. DPA with brush applicator[2]	0	2	--
Stored 2 wks., then 2,000-p.p.m. 42% W. P. DPA dip[3]	0	4	12.6
Wash and brush, 1,800-p.p.m. Stop-Scald dip[4]	0	3	11.7
1,800-p.p.m. Stop-Scald dip, then brushed wet	0	9	--
1,800-p.p.m. Stop-Scald with brush applicator[2]	0	1	--
Stored 2 wks., then 1,800-p.p.m. Stop-Scald dip[3]	2	21	12.8

[1] Values are means of duplicate boxes stored at Greencastle, Pa., 1960-61 season. Fruit picked, treated, and stored Oct. 11, 1960; initial firmness 17.5 pounds. There was no chemical injury from any treatment, but the 42 percent wettable-powder DPA left a powdery residue on many apples.

[2] A drip-type brush applicator was used.

[3] Stored 2 weeks at 31°F., then treated with specified chemical and returned to storage for 5 1/2 additional months.

[4] There was still good coverage with Stop-Scald on April 13 on all lots receiving this chemical, as indicated by fluorescence under UV light.

TABLE 18.--Effect of various treatments on scald, chemical injury, and firmness of York Imperial apples stored 6 months at 31° to 32°F., then held 6 days at 70°[1]

Prestorage treatment[2]	Scald		Chemical injury	Firmness
	Severe	Total		
	Percent	Percent	Percent	Pounds
Control, untreated	6	16	--	14.1
Oiled wraps	1	6	0	14.7
1.5-mg. DPA oiled wraps	0	0	0	14.0
1,000-p.p.m. DPA dip	0	0	1	14.6
2,000-p.p.m. DPA dip	0	0	4	14.3
937-p.p.m. Stop-Scald dip	0	1	0	14.3
1,875-p.p.m. Stop-Scald dip	0	0	0	14.0
2,000-p.p.m. DPA tree spray	2	7	1	14.8
2,811-p.p.m. Stop-Scald tree spray	2	14	0	14.7

[1] Values are means of 2 tests with 2 or 3 boxes per treatment (400-600 apples), 1959-60 season. Fruit picked Oct. 14 and 19, 1959; treated and stored the following day at Berryville, Va., and Paw Paw, W. Va. Initial firmness 20.5 and 18.0 pounds.

[2] DPA treatments include 0.05 percent of Tween-20 as a wetting agent. Spray treatments were applied 24 to 40 hours preharvest.

TABLE 19.--Effect of various treatments on scald and firmness of Red York apples stored 5 1/2 months at 31° to 32°F., then held 7 days at 70°[1]

Prestorage treatment	Scald		Firmness[1]
	Severe	Total	
	Percent	Percent	Pounds
Control, untreated	7	16	17.3
Oiled wraps	1	3	18.3
1.5-mg. DPA wraps	0	1	19.6
2,000-p.p.m. DPA dip with Plyac	0	0	17.8
1,000-p.p.m. 42% W. P. DPA dip	0	0	17.9
2,000-p.p.m. 42% W. P. DPA dip	0	0	17.0
2,000-p.p.m. 42% W. P. DPA dip, then brushed within 30 minutes	1	1	18.4
1,800-p.p.m. 70% Stop-Scald dip	0	0	17.4
3,600-p.p.m. 70% Stop-Scald dip	0	0	17.6
2,000-p.p.m. 80% Stop-Scald dip	0	1	17.9
1,800-p.p.m. 70% Stop-Scald dip, then brushed within 30 minutes	0	0	17.6

[1] Values are means of duplicate tray-packed boxes (200-226 apples), 1960-61 season. Fruit picked Oct. 6, treated and stored Oct. 7, 1960, at Charles Town, W. Va. Initial fruit firmness 20.7 pounds.

TABLE 20.--Effect of various treatments on condition of Arkansas apples stored 6 months at 32° to 33°F. in boxes with various types of liners and then held 6 days at 70°[1]

Type of box liner and prestorage treatment	Scald		Firmness	Internal breakdown	Weight losses
	Severe	Total			
	Percent	Percent	Pounds	Percent	Percent
Paperboard liner:					
Control, untreated	85	97	12.7	4	6.2
Oiled wraps	42	80	13.4	0	5.1
1.5-mg. DPA wraps	1	11	13.1	0	5.5
1.5-mg. DPA wraps (yr. old)	50	85	--	0	--
1.5-mg. DPA oiled wraps	0	6	13.8	0	5.6
2.0-mg. DPA wraps	2	18	13.6	0	4.3
2,000-p.p.m. DPA dip	0	0	12.5	0	6.4
1,000-p.p.m. DPA dip	0	1	13.1	0	6.9
Perforated polyethylene:[2]					
Control, untreated	92	99	11.4	47	1.9
Oiled wraps	46	85	12.4	11	1.8
1.5-mg. DPA wraps	0	2	11.9	26	1.4
2,000-p.p.m. DPA dip	0	0	11.6	38	2.3
Sealed polyethylene:					
Control, untreated	68	88	14.2	13	1.9
Oiled wraps	23	67	14.7	0	1.6
1.5-mg. DPA wraps	0	3	13.9	2	1.6
2,000-p.p.m. DPA dip	0	0	13.9	3	1.4

[1] Values are means of 2 tests of 3 boxes each (6 boxes), 1 in 1956-57 and 1 in 1957-58. Fruit picked Oct. 15, 1956, and Oct. 16, 1957, treated and packed the following day at Beltsville, Md. Initial fruit firmness was 22.3 pounds in 1956 and 22.2 pounds in 1957.
[2] Perforated with four 1/8-inch holes. All film liners were 1.5-mil film.

TABLE 21.--Effect of various treatments on scald and firmness of Grimes Golden apples stored 4 months at 31° to 32° F., then held 6 days at 70°[1]

Prestorage treatment	Scald		Firmness
	Severe	Total	
	Percent	Percent	Pounds
Control, untreated	1	58	8.7
Oiled wraps	0	2	9.5
1.5-mg. DPA wraps	0	2	8.8
1.5-mg. DPA oiled wraps	0	0	8.9
1,000-p.p.m. DPA dip	0	0	8.5
1,000-p.p.m. DPA box spray	0	0	8.3

[1] Data based on triplicate boxes of each treatment, 1958-59 season. Fruit picked Sept. 30, treated Oct. 10, 1958, at Paw Paw, W. Va. Initial firmness 19.0 pounds. DPA dip and spray treatments included 0.1 percent of Tween-20 as a wetting agent.

TABLE 22.--Effect of various treatments on scald, firmness, and weight loss of Grimes Golden apples stored 3 1/2 months at 31° F. in various types of box liners, then held 6 days at 70°[1]

Type of box liner and prestorage treatment	Scald		Firmness	Weight losses
	Severe	Total		
	Percent	Percent	Pounds	Percent
Paperboard liner:				
Control, untreated	6	35	9.6	6.1
Oiled wraps	3	8	10.5	5.3
1.5-mg. DPA wraps	0	0	--	5.1
1.5-mg. DPA oiled wraps	0	0	--	5.5
2,000-p.p.m. DPA dip	0	0	--	5.5
1,000-p.p.m. DPA dip	0	0	--	4.8
Perforated polyethylene:[2]				
Control, untreated	40	74	11.2	2.2
Oiled wraps	2	13	11.3	2.2
1.5-mg. DPA wraps	0	0	--	2.1
2,000-p.p.m. DPA dip	0	0	--	1.9
Sealed polyethylene:				
Control, untreated	6	21	12.7	1.6
Oiled wraps	2	7	12.5	2.5
1.5-mg. DPA wraps	0	0	--	1.4
2,000-p.p.m. DPA dip	0	1	--	1.6

[1] Data based on 2 tests of 3 boxes each per treatment, 1956-57 and 1957-58 seasons. Fruit picked Sept. 25, 1956, and Sept. 26, 1957; treated and stored Sept. 27, 1956, and Oct. 3, 1957, at Beltsville, Md. Initial firmness 21.9 pounds in 1956 and 21.0 pounds in 1957.

[2] Perforated polyethylene liners had four 1/8-inch holes; liners were 1.5-mil film.

TABLE 23.--Effect of various treatments on scald, chemical injury, and firmness of Grimes Golden apples stored 3 1/2 months at 31° F., then held 6 days at 70°[1]

Prestorage treatment	Scald		Chemical injury	Firmness
	Severe	Total		
	Percent	Percent	Percent	Pounds
Control, untreated	8	32	--	10.4
Oiled wraps	1	8	0	11.2
1.5-mg. DPA oiled wraps	0	0	0	10.8
2,000-p.p.m. DPA dip + Plyac	0	0	[2] 15	10.1
2,000-p.p.m. 42% W. P. DPA dip + Plyac	0	0	0	10.7
1,800-p.p.m. 70% Stop-Scald dip	0	0	0	10.7
2,000-p.p.m. 80% Stop-Scald dip	0	0	0	10.4
1,800-p.p.m. 70% Stop-Scald dip (yr. old)[3]	0	0	0	9.9

[1] Data based on duplicate boxes per treatment stored at Greencastle, Pa., 1960-61 season. Fruit picked Sept. 28, treated and stored Oct. 6, 1960. Initial firmness 16.7 pounds.
[2] Crystal burn at calyx and stem cavities.
[3] This treatment was made using one-year-old Stop-Scald.

TABLE 24.--Effect of various treatments on scald, shriveling, and firmness of Golden Delicious apples stored at 31° to 32° F., than held 6 days at room temperature

Test number and prestorage treatment[1]	Scald	Chemical injury	Fruit shriveled	Firmness
	Percent	Percent	Percent	Pounds
Test No. 1 (stored 6 1/2 months):				
Control, untreated	9	--	6	10.8
Oiled wraps	5	0	18	10.0
1.5-mg. DPA wraps	1	0	27	9.8
2,000-p.p.m. DPA dip + Tween-20	0	[2] 100	14	11.1
3,000-p.p.m. DDU dip + Tween-20	4	0	10	10.8
Perforated poly liner	25	--	0	10.3
Sealed poly liner	9	--	0	10.7
Polyethylene emulsion dip[4]	16	0	26	11.6
Test No. 2 (stored 6 months):				
Control, untreated	0	--	86	9.4
2,000-p.p.m. DPA + Tween-20	0	[2] 95	85	7.7
1,875-p.p.m. Stop-Scald dip	0	0	74	9.3
3,000-p.p.m. DDU dip + Tween-20	0	0	93	9.0
5,000-p.p.m. DDU dip + Tween-20	0	0	68	8.2
Test No. 3 (stored 5 months):				
Control, untreated	0	--	24	11.7
Poly liner, untreated	0	--	0	11.1
Poly liner + 1,800-p.p.m. 70% Stop-Scald dip.	0	0	0	10.9
Poly liner + 2,000-p.p.m. 80% Stop-Scald dip.	0	0	0	11.0
Poly liner + 1,500-p.p.m. 42% W. P. DPA dip..	0	[3] 0	0	10.7

[1] Values are means of duplicate boxes. Poly liners had a folded top closure. DDU is dimethyl-diphenyl-urea. Tween-20 (0.05 percent) used as wetting agent where indicated.
[2] Light skin burning or russetting over entire surface caused by alcohol emulsions of DPA.
[3] No skin burning or russetting from this wettable powder type of DPA.
[4] Diluted 1:4 parts of water.

TABLE 25.--Effect of length of dip and wetting agents on Stop-Scald coverage on 4 apple varieties, as indicated by fluorescence[1]

Variety and treatment	Fluorescence rating under UV light[2]	
	5-second dip	30-second dip
Winesap:		
Control, no dip	0	0
Stop-Scald	2.8	4.0
Stop-Scald plus Tween-20	2.8	4.0
Stop-Scald plus Plyac	2.8	4.0
Red Delicious:		
Control, no dip	0	0
Stop-Scald	2.8	2.8
Stop-Scald plus Tween-20	2.8	3.4
Stop-Scald plus Plyac	2.8	3.4
Golden Delicious:		
Control, no dip	0	0
Stop-Scald	2.4	3.8
Stop-Scald plus Tween-20	2.4	3.8
Stop-Scald plus Plyac	2.2	3.6
Grimes Golden:		
Control, no dip	0	0
Stop-Scald	1.2	1.6
Stop-Scald plus Tween-20	1.2	1.8
Stop-Scald plus Plyac	1.2	1.6

[1] Values are rating means of 5 apples, April 1961. Stop-Scald used at 1,800 p.p.m. Fruit temperature 40° to 45° F.; emulsion temperature 70° to 75° F. Tween-20 tested at 0.1 percent; Plyac at 1 pint/100 gallons (937 p.p.m.).

[2] On the 0-6 rating system for coverage: 0 = none, 1 = poor, 4 = good, and 6 = excellent coverage.

TABLE 26.--Effect of emulsion temperature and fruit temperature on Stop-Scald coverage on 4 apple varieties as indicated by fluorescence[1]

Variety and temperature of Stop-Scald dip	Fluorescence rating under UV light[2]	
	Warm fruit (70°)	Cool fruit (40°)
Winesap:		
40° F. emulsion	3.6	3.8
60° F. emulsion	3.6	3.8
80° F. emulsion	3.8	3.8
100° F. emulsion	4.0	4.0
120° F. emulsion	4.6	4.6
Red Delicious:		
40° F. emulsion	3.0	2.6
60° F. emulsion	3.0	3.0
80° F. emulsion	2.8	3.4
100° F. emulsion	3.6	3.4
120° F. emulsion	4.0	3.6
Golden Delicious:		
40° F. emulsion	3.0	3.0
60° F. emulsion	3.0	3.0
80° F. emulsion	3.2	3.0
100° F. emulsion	3.8	4.0
120° F. emulsion	5.0	4.4
Grimes Golden:		
40° F. emulsion	2.8	2.2
60° F. emulsion	3.2	2.4
80° F. emulsion	3.6	2.6
100° F. emulsion	4.2	3.0
120° F. emulsion	4.8	3.4

[1] Values are rating means of 5 apples, April 1961; Stop-Scald used at 1,800 p.p.m. as a 5-second dip.

[2] On the 1-6 rating system for coverage: 1 = poor, 4 = good, and 6 = excellent coverage.

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