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Effect of Butylated Hydroxytoluene (BHT) on Apple Scald[1]

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Abstract. 'Cortland' and 'Delicious' apples were treated with 2 concn of butylated hydroxytoluene (BHT) and 3 levels of diphenylamine (DPA) at 3 temp levels over a 2-year period. On 'Cortland' apples, BHT at 10,000 ppm reduced scald as effectively as 2,000 or 4,000 ppm DPA. BHT also reduced scald on 'Delicious'. BHT residue analyses indicated that most of the BHT remained in the peel of the apple, but the residue was greatly reduced in cold storage within 72 hr after treatment.

Control of storage scald of apples continues to be a problem for the commercial apple grower. Although scald has been studied for over 75 yr, the exact nature and cause of scald is still unknown. Some researchers believe that scald is caused by the accumulation of volatile substances in the skin of the apple (2, 8). Other investigators believe that the causal material is not volatile but may be a product (α-farnesene) of chemical oxidation (6). At the present time, there is no definite explanation of the exact causal agent or specific chemical reaction responsible for scald.

In the past, ventilation (5), oiled wrappers (1, 2), polyethylene box liners (3, 4), and pre-storage CO_2 treatment of the fruit (7) were some of the means of reducing scald. In 1956, Smock (9) reported scald reductions with diphenylamine (DPA). Since then, this chemical has been adopted as one of the standard commercial materials for scald reduction in the U. S., but it is not presently cleared for use in some foreign markets. For this reason effective substitutes for DPA should prove useful to the export trade. One such experimental material is reported here.

Materials and Methods

In 1970, 'Cortland' apples were dipped immediately after harvest (September 15) in 20°C suspensions of 10,000 or 5,000 ppm BHT[3], or in 4,000 or 1,000 ppm DPA, or in 35°C suspensions containing 5,000 ppm BHT or 1,000 ppm DPA. Tween 20 wetting agent was added at the rate of 7,000 ppm to all suspensions. Treated fruit after draining was stored immediately at 0°C ± 1°. The following year both cultivars were similarly treated 1 day after harvest with a 20°C suspension of 10,000 ppm BHT plus 5,000 ppm Tween 20 prior to storage. In both years, the apple boxes were randomly re-positioned at 2-week intervals throughout the storage period to avoid influence of location in storage on scald development.

On March 9, 1971 and February 9, 1972, fruit was removed from storage to room temp (22°C) for 6 days, and scald records were taken. The fruit was graded into 4 classes; 1) clean, no scald; 2) slightly scalded, when up to 5% of the surface was affected with comparatively light-colored scald; 3) medium scald, when the area affected was from 5 to 25% of the surface, with light to dark brown scald; 4) severe scald, 25% or more of the surface affected and usually some of the area dark brown in color. Clean and slight classifications were still marketable, while medium and severe classifications were considered unmarketable (8). In 1971, samples from BHT-treated and control fruit were taken for chemical analysis: apples treated with 5,000 ppm BHT dips at 20°C were also analyzed for residue on scalded and non-scalded sides of the fruits.

A 40 to 50 g portion of sliced or chopped apple, containing the peel and flesh of separate samples of core, flesh, and peel, were extracted by blending with methylene chloride and anhydrous sodium sulfate in a Waring blender and filtering through Celite. The extract was concd in a Kuderna-Danish evaporative concentrator, passed through a short Florisil column to remove pigments and other natural extractives, then concd to 1 ml. Solutions not analyzed immediately were stored under N_2.

BHT residue was determined on a Varian Model 1800 gas chromatograph equipped with flame ionization detectors using a 6 ft 1/8 inch SS column packed with 15% DEGS on 80/100 mesh Gas-Chrom P. With a carrier gas (N_2) flow of 24 cc/min separation of BHT from natural components in the extract was achieved with isothermal operation at 160-170°C.

Results and Discussion

Results indicated that BHT applied as a 20°C dip of 10,000 ppm effectively controlled scald on 'Cortland' and 'Delicious' apples (Tables 1 and 2). On 'Cortland' apples, warm dips of

Table 1. Effect of various dips on apple scald of 'Cortland' (1970-71).

Dip treatment	Marketable fruit (%)
10,000 ppm 20°C BHT	100
5,000 ppm 20°C BHT	72
4,000 ppm 20°C DPA	100[z]
1,000 ppm 20°C DPA	58
10,000 ppm 35°C BHT	97
5,000 ppm 35°C BHT	95
1,000 ppm 35°C DPA	94
Water 35°C Control	5

[z]Injury occurred on 50% of the fruit.

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[3]BHT suspension was prepared and supplied by Eastman Chemical Products, Inc., DPI Division, Kingsport, Tenn.

Table 2. Effect of various dips on apple scald of 'Cortland' and 'Delicious' apples (1971-72).

Cultivar	Dip treatment (20°C)	Marketable fruit (%)
Cortland	10,000 ppm BHT	99.1
	2,000 ppm DPA	97.6
	NONE	12.4
Delicious	10,000 ppm BHT	91.8
	NONE	19.8

Table 3. Residue of BHT on 'Cortland' apples[z] (1970-71).

Dip treatment	Residue (ppm)
10,000 ppm BHT at 20°C	3.76
5,000 ppm BHT at 20°C	1.46
10,000 ppm BHT at 35°C	3.02
5,000 ppm BHT at 35°C	1.95

[z]Apples were treated on September 15, 1970, and analyses were made after removal from storage March 15, 1971.

Table 4. Distribution of BHT residue in 'Cortland apple[z] (1970-71).

Tissue sampled	Residue (ppm)
Peel	14.0
Flesh	0.30
Core	0.72

[z]Apples were dipped in 10,000 ppm BHT suspension before storage, September 15, 1970 and analyses were made after removal from storage March 15, 1971.

Table 5. Residue of BHT on scalded and non-scalded sides of 'Cortland' apples dipped in 20°C 5,000 ppm suspension and stored for 6 months (1970-71).

Apple	Residue (ppm) Scalded side	Non-scalded side
A	2.04	1.41
B	1.01	1.03
C	1.42	1.40

both BHT and DPA at the lower concn were more effective in reducing scald than cold dips. Injury occurred on 'Cortland' apples treated with 4,000 ppm DPA.

Differences in BHT residue between cold and hot dipped apples were inconsistent (Table 3). At 35°C, residues of the 10,000 ppm BHT dip were lower than those of the same concn at 20°C, while the reverse was true at the low concn. The highest BHT concn occurred in the peel of the apple (Table 4). Core and flesh concn were quite low, with the core having approx double the concn of BHT that occurred in the flesh. High core concn of the chemical may have resulted from BHT dip entering the calyx end of the fruit. Residue data (Table 5) indicated no apparent correlation between the amount of BHT residue and scald after removal from storage.

On April 9, 1971, uniform, untreated 'Cortland' apples were dipped in 10,000 ppm cold BHT suspension and a composite sample of flesh and skin analyzed for residue 4 hr after treatment. The samples had 20 ppm BHT residue. During the next 72 hr at 0°C, BHT residue decreased to 7 ppm in these tissues.

An effective substitution of BHT for DPA may open new possibilities for expanded export of apples to countries not presently accepting DPA-treated fruit, but additional research is needed. BHT is cleared at 100 ppm residue for use in vegetable oils, edible fats, chewing gum, rubber, food packaging, etc.; but, not for apples.

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