Influence of Postharvest Handling on the Concentration of Pesticide Residues in Peach Peel

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Abstract. To discern how the packing process influences pesticide residue loads on peach (Prunus persica L. Batsch) fruit; postharvest, post hydrocooled, and post brushed fruit were assessed for levels of several pesticides. The packing house process reduced pesticide residue levels on fresh peaches to levels that were generally below detection limits of our assays in 1998. Carbaryl and captan residues from field packed fruit were 32.2% and 21.9%, respectively, of that found in the peel of fruit processed in the packing house in 1998. Carbaryl levels were not reduced by hydrocooling but postharvest brushing reduced pesticide residues up to 94% in fruit peel. Across processing operations and cultivars assessed in 1999, hydrocooling, hydrocooling plus brushing, and brushing alone removed 37%, 62%, and 53%, respectively, of the encapsulated methyl parathion residues from fruit peel. Hydrocooling had the greatest impact on phosmet removal from peel, reducing levels by 72.5%. After hydrocooling, phosmet was 5.7% following brushing in one-half of the subsequent samples. This increase occurred at all three farms, suggesting that periodic cleaning of brushes may be necessary to prevent later contamination of peach peel with pesticides. In the only example in which propiconazole residue remained on peaches at picking, it was removed most effectively (69%) by the brushing operation. Nearly 31% of the propiconazole was removed in the hydrocooler. The packing process before shipment to retail outlets was generally effective in the removal of pesticides that may be present on peel at the time of harvest. Assessment of pesticide residue levels in peach flesh was uniformly below the levels of detection in our assays, suggesting that the classes of pesticide analyzed in peaches were not transperdermal.

Knowledge of pesticide residues in our food supply influences decisions made by regulatory agencies to reduce risks to consumers from dietary intake of pesticides. Generally, fruits and vegetables have been assessed for pesticides without consideration of the effects of postharvest handling on the residue load (Erner and Coggins, 1989; Matten et al., 1990; Metwally et al., 1997; Schattenberg and Hsu, 1992). Additionally, there is increased interest by brokers in field run fruit and by growers in the market for juicing fruit. Therefore, an understanding of the impact of postharvest handling on the reduction of pesticide residues is relevant.

Two aspects of the packing house process, hydrocooling and brushing, are likely to impact peel residue levels of packaged peaches (Prunus persica L. Batsch). Hydrocooling serves two roles in the packing process: quick removal of fruit field heat and removal and reduction of fruit pathogenic organisms that shorten fruit shelf life (Mitchell, 1989). Brushing is conducted on the packing line to remove trichomes that are unsavory to consumers and to evenly distribute waxes on the fruit surface (Mitchell and Kader, 1989). The impacts of these packing house processes on pesticide residue levels in the peel are important, because portions of the packing house process are circumvented in “tree ripe” programs. The isolated peel was placed in a clean glass jar and frozen at –20 °C until analysis was performed at the pesticide analysis facility at the Univ. of Georgia Agricultural and Environmental Services Laboratory, Athens, Ga.

1999 Trial. During 1999, more lots were sampled throughout the season and from different farms to reflect changes in field operations that may influence residue levels. Harvest dates and dates and rates of application in 1999 per farm operation are presented in Table 1. Samples were collected from field bins before and after hydrocooling, and from the packing line after brushing to determine which operation had the greatest influence on reducing pesticide residues. “Brushing only” fruit did not undergo hydrocooling. Farm records indicated different spray rates and protocols for the three operations, but all operations applied pesticides by an airblast sprayer at ~153 L·ha–1. Relative to 1998, the detection from the early (‘Juneprince’), middle (‘Harvester’), late (‘Flameprince’ and ‘O’Henry’) and very late (‘Parade’) harvest seasons, fairly represent the full range of pesticide use patterns. Three different grower operations were sampled based on the differences in field operations among those operations (Table 1). Farm A and C sprayed methyl parathion from every row middle at a lower rate than Farm B where methyl parathion was sprayed in alternate row middles. Farm C was located in an area with slightly different insect and disease pressures, resulting in somewhat reduced application rates and frequencies.

1998 Trial. ‘Flameprince’ and ‘O’Henry’ peel samples, taken before and after packing house process, were analyzed for methyl parathion, fenbuconazole, propiconazole, captan and carbaryl. Farm records indicated the following spray rates were applied by an airblast sprayer at 935 L·ha–1: 1.17 L·ha –1 methyl parathion (Pennacap M®; Elf Atochem, Philadelphia) on 8 Apr. 1998, 15 May 1998, and 4 June 1998; 140 g·ha–1 fenbuconazole (Indar® 75W; Rohm and Haas, Philadelphia) on 15 June 1998; 6.7 kg·ha –1 (Capitan® 50W; Micro Flo, Lakeland, Fla.) on 23 June 1998; and 5.3 kg·ha–1 carbaryl (Sevin® 80W; Syngenta, Research Triangle Park, N.C.) on 19 June 1998. ‘Flameprince’ were harvested 17 July 1998 and ‘O’Henry’ on 24 July 1998. Fruit samples were collected prior to hydrocooling (cooling fruit with ~3 °C recycled water spray) and at the end of the packing line. Fruit collected after the packing process had undergone hydrocooling and brushing. Hydrocooler water contained 25–50 free chlorine mg·L–1. Fruit were in the hydrocooler for ~40 min at ~3 °C and brushed for 25–30 s. Sampled fruit were transported for up to 30 min. in air conditioning and immediately peeled by hand with stainless steel knives in the lab. About 25% of the peel from each of three fruit was peeled in long strips along the middle portion of the fruit longitudinally from pedicel to pistil scar or tip. The peel was coarsely chopped and 2 g of the peel composite constituted a single sample. Each cultivar assessed was done so in three replicates for each grower/packer in the study. The isolated peel was placed in a clean glass jar and frozen at –20 °C until analysis was performed at the pesticide analysis facility at the Univ. of Georgia Agricultural and Environmental Services Laboratory, Athens, Ga.

Materials and Methods

In these experiments, peach fruit peel was analyzed for several pesticides used as cover sprays during fruit development in the Southeastern U.S. peach industry. Sampling focused on peel rather than whole fruit to capture the majority of pesticide residues without the diluting effect of the peach flesh. The studies, performed on several cultivars of fruit chosen from the early (‘Juneprince’), middle (‘Harvester’), late (‘Flameprince’ and ‘O’Henry’) and very late (‘Parade’) harvest seasons, fairly represent the full range of pesticide use patterns. Three different grower operations were sampled based on the differences in field operations among those operations (Table 1). Farm A and C sprayed methyl parathion from every row middle at a lower rate than Farm B where methyl parathion was sprayed in alternate row middles. Farm C was located in an area with slightly different insect and disease pressures, resulting in somewhat reduced application rates and frequencies.

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Table 1. Application and sample dates per peach cultivar with pesticide application rates on three farms. All farms applied their pesticides in 100-gal volume per acre.

| Farms, cultivars, and harvest date | Dates of pesticide application | Methyl parathion | Phosmet | Propiconazole | Captan | Carbaryl |
|-----------------------------------|-------------------------------|-----------------|---------|---------------|--------|---------|
| **Farm A**                        |                               |                 |         |               |        |         |
| Juneprince 6/14/99                |                               | 4/6/99          | 4/22/99 | 3/27/99       | 5/25/99| 6/1/99  |
| Harvester 6/29/99                 |                               | 4/6/99          | 5/18/99 | 4/1/99         | 5/6/99 | 6/14/99 |
| Flameprince 8/3/99               |                               | 4/5/99          | 5/10/99 | 3/29/99        | 5/20/99| 7/3/99  |
| **Farm B**                        |                               |                 |         |               |        |         |
| Juneprince 6/14/99                |                               | 3/30/99         | 4/17/99 | 3/26/99        |        |         |
| Harvester 6/29/99                 |                               | 4/6/99          | 4/24/99 | 3/30/99        |        |         |
| O’Henry  7/27/99                  |                               | 4/16/99         | 5/11/99 | 6/22/99        |        |         |
| **Farm C**                        |                               |                 |         |               |        |         |
| O’Henry  8/2/99                   |                               | 4/12/99         | 4/26/99 | 4/6/99         | 6/24/99| 6/23/99 |
| Flameprince 8/14/99              |                               | 4/15/99         | 4/29/99 | 4/6/99         | 6/30/99| 7/28/99 |
| Parish 6/29/99                    |                               | 4/19/99         | 5/12/99 | 6/29/99        | 7/11/99| 7/22/99 |

*: application rate used by each farm.

Farm B applied methyl parathion in alternate row middle pattern throughout the season.

A 20-g aliquot of the ground peach flesh from three fruit constituted a single sample. A mean flesh residue value was obtained by averaging the residue levels of three replicate samples pooled from three fruit for each field packed or postharvest packing step. When appropriate, means were separated by Duncan’s multiple-range test (Little and Hills, 1978).

Results and Discussion

The U.S. Environmental Protection Agency’s (USEPA) whole fruit tolerance maximum (USEPA, 1999) for each pesticide tested is listed in Tables 3 and 4. In all cases, the residue levels in peel sampled from field packed fruit were below USEPA tolerance levels established for whole fruit (peel plus flesh). Our study is unique in that the fruit peel (Table 3 and 4) minus the flesh (Table 5) was used in our assays to increase the likelihood of detecting any pesticide residue present on the fruit.

Therefore, the data in these tests must be viewed with caution. With whole fruit weights ranging from 87–135 g, our 20-g peel samples from three fruit represent 4.9% to 7.7% of the whole fruit mass. Thus, the flesh diluted the residue concentration in whole fruit samples by an average of 12.3-fold (range of dilution = 9 to 13, data not shown). Avoidance of this 12-fold dilution, allowed us to determine residue levels on washed and brushed fruit, within the detection range of our protocols and instrumentation. As an example, had we used whole fruit samples, the methyl parathion level for the ‘O’Henry’ fruit from Farm B (Table 4) would have been below the detection limit for each stage of the packing line operation tested and would have been just at the detection level (0.05 µg g⁻¹) in the field packed fruit, and all other methyl parathion tests in 1999 would have been below the detection limit.

Dates of pesticide application and rates of application per farm operation are presented in Table 1. Each pesticide treatment was performed in triplicate on each farm for each field packed or postharvest operation. When appropriate, means were separated by Duncan’s multiple-range test (Little and Hills, 1978).
The two operations together resulted in a 61.8% reduction in methyl parathion residue.

Phosmet residue was reduced 72.5% by hydrocooling but increased 5.7× by brushing in one-half of the samples after hydrocooling. The largest increase (+940) was over a very small value, 0.005 µg g⁻¹, in the ‘O’Henry’ cultivar at Farm C (Table 4), and not above theUSEPA tolerance level for phosmet. This increase happened in all three farms, suggesting that periodic cleaning of brushes or other aspects of the line may be necessary to prevent later contamination of peach peel with pesticides, particularly phosmet. Propiconazole was detected only in ‘Flameprince’ at Farm A. In that case, brushing alone removed 69.3% of propiconazole residue, but hydrocooling did not reduce residue levels. The operations together reduced propiconazole residue levels by at least 88.3%, well below the tolerance level of 1 µg g⁻¹ (Table 3 and 4) and even in one case below the level of detection for the analysis (0.05 µg g⁻¹). Generally, methyl parathion levels were substantially reduced with hydrocooling and brushing operations. Across all cultivars and farms, brushing alone reduced methyl parathion residues by 52.7%, while hydrocooling fruit accounted for a 37% reduction. The two operations together resulted in a 61.8% reduction in methyl parathion residue.

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for further reduction of values if whole fruit had been analyzed, postharvest values should be substantially lower than USEPA tolerance levels for whole fruit. The values found in field packed fruit were reduced even more through washing and brushing operations in the packing process. Clearly, the packing process before shipment to retail outlets is extremely effective in removing the pesticide load that may be present at the time of harvest. The washing and brushing operations each contributed to the removal of the pesticides with brushing having the greatest impact on residue reduction. It is evident, however, that care should be taken periodically to clean the brushes or possibly rollers on the packing line and to replace hydrocooler water more often to remove pesticide residues that can accumulate and contaminate clean fruit. Continued research will assess the cleanup of packing lines and appropriate turnover of hydrocooler waters to avoid pesticide reloading on peel surfaces.

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Table 4. Peel residues of five pesticides from three farms and four cultivars in 1999, and maximum tolerance values (U.S. Environmental Protection Agency).

| Farm | Methyl parathion | Phosmet | Propiconazole | Captan | Carbaryl |
|------|------------------|--------|---------------|--------|----------|
| Juneprince | Field | 0.05 a | <0.005 | <0.050 | <0.200 | <0.05 a |
| | Post-cooler | 0.190 b | <0.005 | <0.050 | <0.200 | <0.05 a |
| | Post-brushes | 0.126 c | <0.005 | <0.050 | <0.200 | <0.05 a |
| | Brushing alone | 0.086 b | <0.005 | <0.050 | <0.200 | <0.05 a |
| O'Henry | Field | 0.116 a | <0.005 | <0.050 | <0.200 | <0.05 a |
| | Post-cooler | 0.179 b | <0.005 | <0.050 | <0.200 | <0.05 a |
| | Post-brushes | 0.105 b | <0.005 | <0.050 | <0.200 | <0.05 a |
| | Brushing alone | 0.078 b | <0.005 | <0.050 | <0.200 | <0.05 a |
| Juneprince | Field | 0.047 a | <0.005 | <0.050 | <0.200 | <0.05 a |
| | Post-brushes | 0.019 c | <0.005 | <0.050 | <0.200 | <0.05 a |
| | Brushing alone | 0.012 a | <0.005 | <0.050 | <0.200 | <0.05 a |

Table 5. Pesticide residues in flesh of peeled peach fruit. Farm C only.

| Farm C | Methyl parathion | Phosmet | Propiconazole | Captan | Carbaryl |
|--------|------------------|--------|---------------|--------|----------|
| Juneprince | Field | 0.213 a | <0.005 | <0.050 | <0.200 | <0.05 a |
| | Post-brushes | 0.097 b | <0.005 | <0.050 | <0.200 | <0.05 a |
| | Brushing alone | 0.086 b | <0.005 | <0.050 | <0.200 | <0.05 a |
| Flameprince | Field | 0.332 a | <0.005 | 0.397 a | 1.808 a | <0.05 a |
| | Post-brushes | 0.126 c | <0.005 | 0.135 b | 1.317 b | <0.05 a |
| | Brushing alone | 0.087 b | <0.005 | 0.100 a | 1.071 a | <0.05 a |
| O'Henry | Field | 0.064 a | <0.005 | 0.302 c | 1.807 b | <0.05 a |
| | Post-brushes | 0.016 c | <0.005 | 0.058 b | 0.889 a | <0.05 a |
| | Brushing alone | 0.009 a | <0.005 | 0.046 b | 0.567 a | <0.05 a |
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558