Persistency of Peracetic Acid Residuals on The Surfaces of Treated Fruits and Vegetables

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Background

Bioside HS 15% (15% PAA, 22% H_2O_2) is used in the processing of fruits and vegetables. The residuals, from the biocide, on the surface of fruits and vegetables are of some concern with certain non-US government regulatory authorities that regulate pesticide residues on food. Note that EPA 40 CFR 180 has declared peroxyacetic acid to be exempt from the requirement of a tolerance when used within the concentration limits set by EPA and FDA guidelines, but this may not be true for other regulatory agencies worldwide. This study was therefore performed to examine the persistency of PAA and H_2O_2 applied to the surface of several fruits and vegetables in order to determine whether any PAA or H_2O_2 residues would be present when the food reaches the consumer. Also, this study calculates the amount of additional residuals remaining on the surface of the fruits and vegetables from the Bioside HS 15% which are unreactive and do not degrade.

Methodology

This study was designed to model the disinfection process and conditions for fruits and vegetables at the highest allowable concentration of PAA (80 ppm). The fruits and vegetables tested included tomatoes, squash, blueberries, and apples. In this study, 80 ppm PAA from Bioside HS 15% was applied to the surface of the produce.

An 80 ppm PAA solution was prepared by adding Bioside HS 15% (0.533 g) to city water (1000.0 g). The solution was tested using the modified DPD method to determine the amount of PAA in the solution. In this case, the concentration of the solution was 87.74 ppm PAA.

The produce was used to simulate the different types of fruits and vegetables being processed. An average surface area was calculated for the different produce and reported in Table 1. An initial weight of the produce was measured before spraying each piece 10 times with 80 ppm PAA solution. Immediately after the spray treatment the produce was agitated to simulate traveling on a conveyor belt then weighed to measure the solution remaining on the produce. The solution was allowed to remain on the produce and then at varying time intervals the solution in contact with the produce was rinsed off with a known volume of water and analyzed using the DPD Colorimeter method to monitor the decay profile of the PAA and H_2O_2. The study was terminated when the PAA levels were below the detection limit of the instrument. The weight of the solution remaining on the produce was used to calculate the amount (mg/kg of produce) of HEDP stabilizer associated with BioSide HS 15%. This is an unreactive chemistry and does not degrade over time.

Results & Discussion

Table 1 displays the weight, surface area, volume, and volume normalized to the surface area for each produce.

Table 1

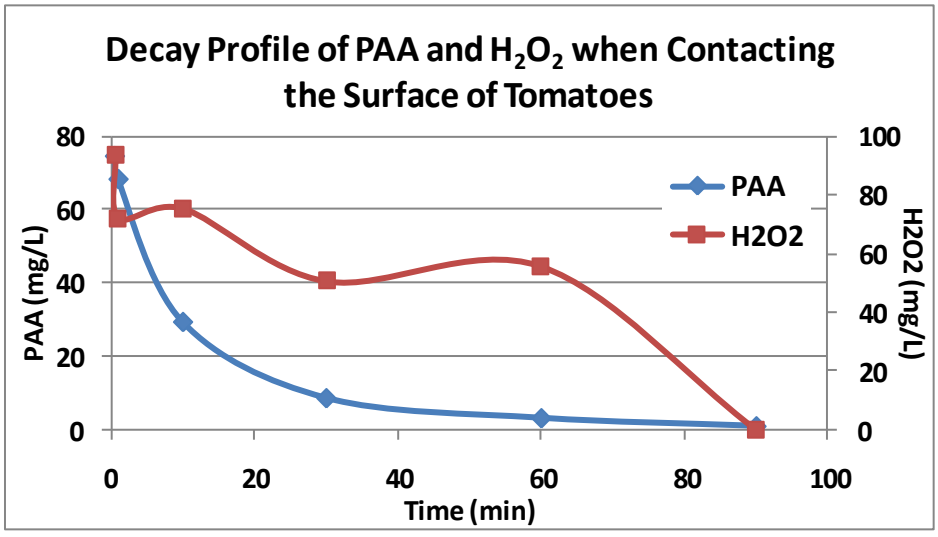
Produce	Average Weight (g)	Average Surface Area (cm^2)	Average Volume Bioside HS 15% Retained (mL)	Volume Normalized to Surface Area (mL/cm^2)
Yellow Squash	112.66	168.17	0.34	0.002
Tomatoes	131.1	150	0.50	0.003
Blueberries (5 berries)	9.135	42.75	0.25	0.006
Fuji Apples	233.77	265.9	0.58	0.002

Even though the weight and size of the produce were different, when the volume of 80 ppm PAA remaining on the produce was normalized for the surface area, the measurements were very small, 0.002 mL/cm^2, 0.003 mL/cm^2, 0.006 mL/cm^2, and 0.002 mL/cm^2 for the yellow squash, tomatoes, blueberries, and apples respectively.

Graphs 1-4 illustrate the decay profiles of PAA and H_2O_2 from Bioside HS 15% in contact with the produce; yellow squash, tomatoes, blueberries, and apples. The initial concentration of the solution was 87.74 ppm PAA.

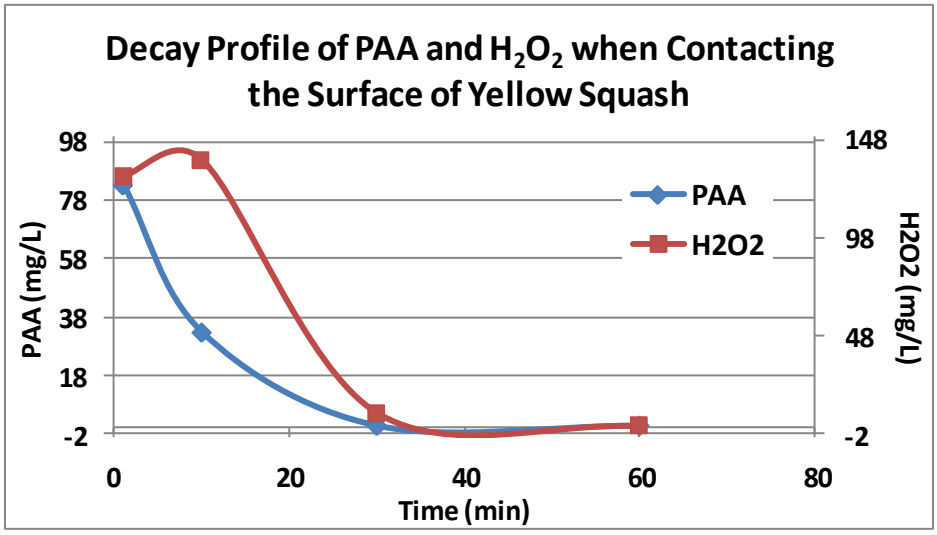
Graph 1 illustrates the instability of PAA and H_2O_2 on the surface of tomatoes. After 30 seconds the initial concentration was at 74.4 ppm PAA and 93.85 ppm H_2O_2. Over time, the concentration of the PAA and H_2O_2 decreased gradually. After 90 minutes, the study was terminated due to the depletion of PAA and H_2O_2 to a non-detectable limit of the instrument.

Graph 1



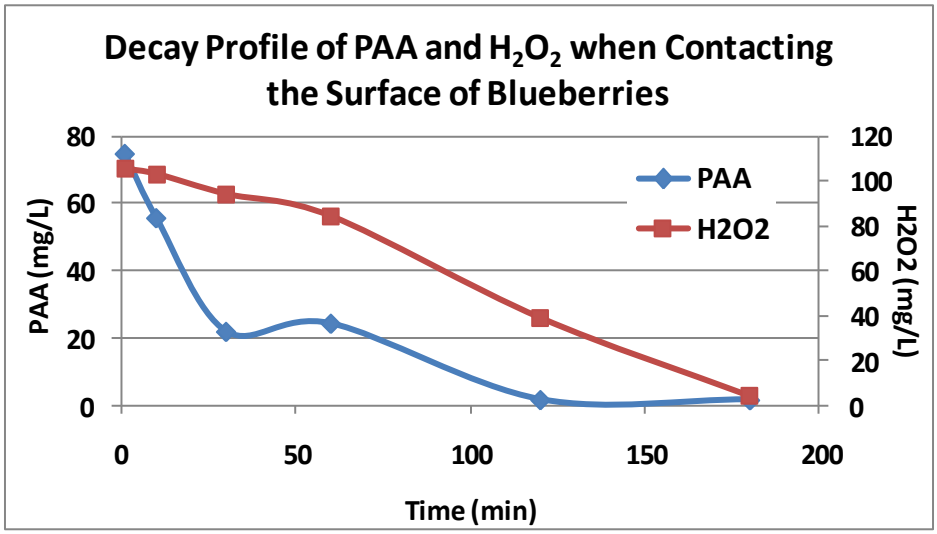
Graph 2 illustrates the instability of PAA and H_2O_2 on the surface of yellow squash. After 10 minutes the initial concentration declined from 87.74 ppm PAA to at 30.74 ppm PAA and 137.58 ppm H_2O_2. After 30 minutes, the concentration of the PAA measured below the detection limit of the instrument and the H_2O_2 decreased to 8.91 ppm. After 60 minutes, the study was terminated due to the depletion of PAA and H_2O_2 to a non-detectable limit of the instrument.

Graph 2



Graph 3 illustrates the instability of the PAA and H_2O_2 on the surface of blueberries (groups of 5 berries). After 10 minutes the initial concentration declined from 87.74 ppm PAA to at 55.65 ppm PAA and 103.05 ppm H_2O_2. After 120 minutes, the concentration of the PAA measured below the detection limit of the instrument and the H_2O_2 had decreased to 40.10 ppm. It was only after 180 minutes was the study terminated due to the depletion of PAA and H_2O_2 to a non-detectable limit of the instrument.

Graph 3



Graph 4 illustrates the instability of the PAA and H_2O_2 on the surface of apples. The surface of an apple is similar to the surface of a tomato therefore ample time was allowed before the first measurement was taken. The solution was allowed to sit for 60 minutes before analyzed. After 60 minutes the initial concentration declined from 87.74 ppm PAA to at 8.78 ppm PAA and 51.28 ppm H_2O_2. After 180 minutes, the concentration of the PAA measured below the detection limit of the instrument and the H_2O_2 decreased to 18.25 ppm. It was only after 240 minutes was the study terminated due to the depletion of PAA and H_2O_2 to a non-detectable limit of the instrument.

Graph 4

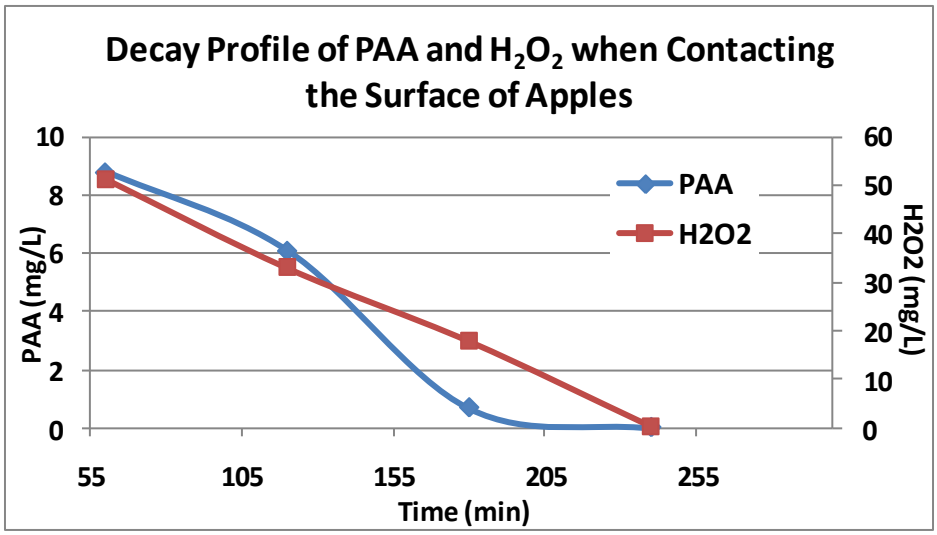


Table 2 displays the measurement of additional residuals from Bioside HS 15% present on the produce after treatment. The additional residuals which do not degrade over time include acetic acid and 1-Hydroxy Ethylidene-1,1-Diphosphonic Acid (HEDP).

Table 2

	Amount of Lingering Residuals (mg residual/g produce)	
Produce	**Acetic Acid**	**1-Hydroxy Ethylidene-1,1-Diphosphonic Acid (HEDP)**
Tomatoes	3.36×10^{-4}	1.46×10^{-5}
Yellow Squash	2.66×10^{-4}	1.16×10^{-5}
Blueberries (5 berries)	2.4×10^{-3}	1.05×10^{-4}
Apples	2.14×10^{-4}	9.54×10^{-6}

Conclusions

- Peracetic Acid was unstable in the presence of the fruits and vegetable used in this study. The produce came from a grocery store therefore it can be assumed to be relatively clean.

The PAA and H_2O_2 will break down more rapidly in the presence of raw unprocessed fruits and vegetables due to any organics that may be present.

- This study modeled the disinfection process and conditions for fruits and vegetables at the highest allowable concentration of PAA (80 ppm). The volume of PAA solution remaining per surface area of produce was calculated to be 0.002 mL/cm^2, 0.003 mL/cm^2, 0.006 mL/cm^2, and 0.002 mL/cm^2 for the yellow squash, tomatoes, blueberries, and apples respectively

- The PAA depletes quicker than the H_2O_2. The PAA persisted for 60 minutes and the H_2O_2 persisted for 90 minutes when in contact with tomatoes. On the surface of yellow squash the PAA persisted for 30 minutes and the H_2O_2 remained for 60 minutes. The persistence of PAA on blueberries was 120 minutes but the H_2O_2 lingered until 180 minutes. And lastly the persistency of PAA and H_2O_2 on apples was 180 minutes and 240 minutes respectively.

- The findings of this study verify that different types of produce treated with the highest concentration of PAA (80 ppm) from Bioside HS 15% under similar disinfecting conditions, will not leave lasting residual on the food after 4 hours. From this, it can be stated that there is no possibility that PAA and H_2O_2 residuals will be present on produce when the product reaches consumers.