THE APPLICATION OF PHOSPHATES IN THE PROCESSING OF PACIFIC SHRIMP, OR WHAT'S SO DIFFERENT ABOUT THIS USE?

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On October 21, 1992, the Seattle office of the U.S. Food and Drug Administration issued an industry advisory that directed that Pacific shrimp processors would have to begin to label the addition of phosphate to their product. This directive changed a practice that had existed for over ten years, since these processors first used phosphates on their shrimp. The processors, with the guidance of various professionals, both academic and otherwise, believed that this application was classed as a "processing aid".

As most of us know, significant quantities of phosphates are used for shrimp processing. Processors on the East and Gulf Coasts use condensed phosphates to retain moisture in the shrimp. If they did not, there would be a significant loss of moisture (and protein) in the freezer, during thawing, and during heat processing. This would create economic losses and customer dissatisfaction. The direct addition of a phosphate solution by processors in the Southeast adds a specific amount of phosphate to the product, and Food and Drug Administration regulations require labelling that declares the presence of phosphate. This is a proper application of the law.

However, with Pacific shrimp (Pandalus jordani), there is a different reason for phosphate use, and I am here to explain that difference to you. As stated, Pacific Coast shrimp processors, along with numerous knowledgable people including the authors noted above, believe that their application of phosphates is covered by 21 CFR Ch. 1, Part 101.100, Section ii, paragraphs (b) and (c), part of what is commonly called the "Processing aid regulation".My presentation today will address the reasons that the previously-named authors, and many others, firmly believe that this use of phosphates is definitely a processing aid, rather than a food ingredient.

First, let us look at two of the paragraphs in the processing aid regulation. Paragraph (b) states that processing aids are "Substances that are added to a food during processing, are converted into constituents normally present in the food, and do not significantly increase the amount of the constituents naturally present in the food." Paragraph (c) says that processing aids may also be "Substances that are added to a food for their technical or functional effect in the processing but are present in the finished food at insignificant levels and do not have any technical or functional effect in that food." Later in this presentation, we will refer back to these two paragraphs. Now, let us look at the processing of Pandalus jordani. Much research has been done on this species of shrimp at the Oregon State University Seafoods Laboratory at Astoria, Oregon.

As many of you already know, this shrimp is much smaller than that which is typically processed by Eastern and Gulf processors, or by those who import green headless shrimp from overseas. Counts may run anywhere from 100 to 350 per pound, in the shell, although harvesting and processing of the smaller sizes, perhaps smaller than 170 per pound, is discouraged, and sometimes even prohibited. This shrimp may be landed at ports from Eureka, California to Westport, Washington, and sometimes even in British Columbia.

Immediately after landing, the shrimp does not process well. Processors determined long ago that allowing P. jordani to age, in ice, for three or four days after catch would improve the ability of the mechanical peelers to remove the shell from the meat. This allows enzymatic action to degrade the connective tissue (collagens) that occur between the musculature and the shell. This action, however, solubilizes some of these tissues, meaning that upon separation, the solubles will then be lost during the intense washing that occurs in a shrimp peeler.

Let's describe the peeling process. Shrimp are delivered to the peeler area in tote bins, with ice still usually present. They are then dumped into the feed hopper on the peeler, where they may remain for several minutes. They then move out of the hopper area on an inclined mesh belt, in a nearly single-thickness layer. The shrimp pass through the cooking area, where they are steamed at 100 degrees centigrade for a period of about 90 to 110 seconds.

After cooking, they immediately fall onto a number of counter- rotating, oscillating rollers that slope down and away from the cooking area. Streams of water under pressure are focused upon these rollers. The loosened shell, along with legs, antennae, and viscera are pinched by the rollers and discharged below. The shrimp flesh, being somewhat soft, slippery and flexible, travels down the rollers and falls into a flume. The shrimp then are flumed into a separator, where any last pieces of shell are removed, then onto an inspection belt prior to freezing.

The industry estimates that up to four gallons of water per pound of shrimp are used after phosphate treatment and cooking, and during the mechanical part of the peeling process.

In the late 1970's Dr. David Crawford, with Dr. Jerry Babbitt, at the Oregon State University Seafoods Laboratory, began to study ways to retain the soluble and insoluble protein lost in the peeling process. The idea was to promote gelatinization of the soluble proteins during cooking. It was noted that considerable amounts of connective tissue were retained in the peeled shell. If the soluble proteins could be gelatinized, this would allow much of the remaining tissue to be pulled from the shell when peeled. Condensed phosphates were selected as the means of performing this action (1).

Initial studies were done with a commercial mixture of mostly sodium tripolyphosphate with some sodium hexa-meta phosphate, called Brifisol^R D-510, from BK Ladenburg Corporation. Work began in the lab, and then progressed to plants where phosphate solutions were applied to the shrimp in the peeler's feed hopper. Results were impressive. It required a couple of years for acceptance, but the industry eventually turned 100% to processing with phosphate.

Concurrent further research by the Seafoods Lab found that a solution of up to 6% phosphate could be used, and that very cold treatment temperatures were necessary for best results. The Laitram PC-A peelers at first allowed the hot condensate from the cooking area to flow back into the feed hopper where phosphates were being applied. It was not long until all of the processors had made modifications to the peelers to reduce temperatures in the feed hopper to as close to 0 degrees Centigrade as possible.

A typical operation utilized a recirculating system with a mixing and holding tank for the phosphate solution, a means of refrigeration to maintain cold temperatures, and screens to keep larger particles of shrimp residue out of the system. After these changes were in place, it was not uncommon for processors to increase recovery of meat by as much as ten percentage points, i.e., from perhaps 21% without phosphate to 31% with phosphate. At the price of peeled shrimp, this was a significant savings.

One other change occurred. Due to the softness of the water on the Oregon Coast, and due to the fact that it is very difficult in plant operations to perform precise recovery analysis due to the variability of Pacific shrimp from tote-to-tote, hour-to-hour, week-to-week or whatever time frame is chosen, most processors changed over to straight sodium tripolyphosphate for the cost savings. It was very difficult in this case to achieve truly accurate recovery information that would have shown the difference that could have been achieved with a more sophisticated phosphate, as can be done in a hard water area or with a different product being treated.

At this time, it should be emphasized that phosphate is applied to the shrimp only before cooking, peeling and washing. Contrary to what some believe, there is no phosphate whatsoever applied afterwards, as will be noted later.

Now, let us address the determination that this is a "processing aid". There is a considerable amount of research that justifies this, in the opinion of the referenced authors and myself, and here is some of this information:

In a 1980 paper (1), Dr. Crawford reported that he had determined that phosphorus content of treated shrimp (as P_2O_5) can vary from 537 to 727 mg/100g wet weight, a variation of 190 mg. He also found that pretreatment solutions as high as 6% produced added phosphorus levels of less than 110 mg/100g wet weight over control samples. His conclusion was that the quantity of phosphorus added to cooked shrimp meat...is somewhat less than the range of phosphorus levels naturally occurring in shrimp.

In 1981, Tenhet and others used radiolabelled phosphorus on both fresh and previously frozen raw, <u>peeled</u> shrimp. STP concentration had to be 5% to 10% with a contact time of <u>at least 20 minutes</u> to achieve uniform distribution throughout the muscle. Note that we are discussing the use of phosphate on unpeeled Pacific shrimp, and for a contact time of approximately 5 to 10 minutes, using 6%--usually less--concentration. It is very likely that phosphate treatment is acting only on the surface of the flesh in our case with Pacific shrimp.

An incorrect idea was recently presented that Pacific shrimp were being treated with phosphate after cooking, causing additional water binding. First, you should know that sodium tripolyphosphate is unstable at elevated temperatures such as in steam cooking. It is quickly and efficiently hydrolyzed to the orthophosphate form, a form naturally occurring in muscle. This molecular form is not active in protein modification, water binding, or sequestration.

A note here, for those who use phosphates, especially those that are more difficult to dissolve, one should never dissolve phosphates in hot water. In fact, you should not even dissolve them in warm water. A good instantized phosphate can be dissolved in cold water.

To point out this hydrolysis effect with scientific studies, Sutton, in 1973 (3), showed that tripolyphosphate was rapidly hydrolyzed to pyrophosphate, then to orthophosphate in cod muscle due to the action of alkaline phosphatases at both 0C and 25C. In 1981, Tenhet and others (4) showed that after two weeks frozen storage, only 12% of total phosphorus in uncooked shrimp muscle corresponded to the originally added STP. By ten weeks, of frozen storage, phosphorus level corresponded to 45% orthophosphate. No heat was applied to facilitate the hydrolysis of the condensed phosphate. It should be very apparent that there is no action whatsoever by the phosphate after cooking, and it is a known fact that there is no phosphate application to the shrimp after cooking. Such application would be a total waste of phosphate and an economic loss.

Another concern has been expressed for the amount of residual phosphate that might remain in cooked shrimp, and the activity of this phosphate. In 1980 Crawford reported (1) that there was an upper limit of 0.258% P_20_5 uptake in processed shrimp, and as noted above, only 12% of the total phosphorous corresponds to added STP, so it is reasonable to conclude that the amount remaining is insignificant. STP averages 58% P_2O_5, therefore there would be only 0.018% remaining. This is a level too low to provide any residual humectant or sequestrant effects, even if this was an active form of phosphate.

There have also been concerns expressed that the use of condensed phosphates prior to cooking and peeling results in increased muscle hydration, or a "humectant" effect. Data from Oregon State University shows that there is no significant difference in moisture content between treated and untreated Pacific shrimp. In 1981, Chu (5) compared treated and untreated shrimp, processed at 3, 4, and 7 days post-catch, held in ice before processing. Untreated, the moisture contents were 79.30, 80.39, and 82.04% respectively. Phosphate treated shrimp, however, showed moisture contents of 80.20, 80.88, and 81.30% respectively; not significantly different. It would appear from this data that the treatment resulted in a more consistent final moisture content. It is therefore very apparent that there is no increased muscle hydration nor is there a humectant effect.

In 1979, Nouchpramool (6) showed that the older the Pacific shrimp (time post-harvest and prior to processing), the greater the moisture content, whether phosphate was used or not. With the use of a 6% solution of condensed phosphate on 2-day old shrimp, moisture content increased only 0.30 to 0.58%, with a mean of 0.44%. Two day old untreated shrimp moisture content varied by

1.84%. Any increase in moisture after treatment with condensed phosphate would be within natural variation. Additional work by Nouchpramool showed that use of phosphate increases the meat yield and not the percentage moisture content.

Also, in 1984, Regenstein (7) evaluated the effect of different phosphates on the water binding potential of seafood muscle. At concentrations of up to 6mM, or about 0.6% orthophosphate, there was no net increase in the muscle's water binding potential. Once again, there is no increased muscle hydration nor is there a humectant effect with the presence of orthophosphates. Our conclusion here can only be that, rather than promote water uptake, the use of phosphates results in a more consistent final moisture content and more predictable process yield. Therefore, there is no significant difference in moisture content between treated and untreated cooked Pacific shrimp.

Again, concerning sequestration of ions, sodium tripolyphosphate is considered to be only a very weak sequestrant. Orthophosphate is not a sequestrant and contributes very little, if at all, to water binding. Therefore, it is again very apparent that there is no increased muscle hydration, nor is there any humectant effect. It is also axiomatic that the addition of water to cooked muscle proteins cannot be affected by polyphosphates!

From all of this, we may conclude that phosphates are used in the mechanical peeling of Pacific shrimp to: (i) Effect dissolution of the connective tissue between the muscle tissue and the shell, and, (ii) To facilitate surface protein gelation and increase peeling recovery. This results in efficient separation of the flesh from the shell and has no further effect after deshelling. Neither moisture content nor phosphate content is significantly increased. This application therefore meets the requirements of the F.D.A. "Processing Aid Regulations".

Now, let us look once more at these regulations. I will again show you the two applicable paragraphs, (b) and (c), and embellish them with my comments: Paragraph (b) states that processing aids are: "Substances that are added to a food during processing, are converted into constituents normally present in the food, and do not significantly increase the amount of the constituents naturally present in the food". Please note that I have underlined the word "significantly". It is quite obvious, that if you consider the data that the authors and I have presented, and especially in light of the use of the underlined word, this paragraph has been satisfied.

Furthermore, paragraph (c) says that processing aids may also be "Substances that are added to a food for their technical or functional effect in the processing but are present in the finished food at <u>insignificant</u> levels and do not have any (<u>further</u>) technical or functional effect in that food." Here, we again find that significance is to be considered. I have also added the word "further" that may not be in the regulation, but can be assumed to exist there. Obviously, if a processing aid had no technical effect whatsoever in the food at any time, there would be no reason to use it at all! Common sense tells us that the concern here is for any further effect in the finished product. Therefore, it is also very apparent that paragraph (c) has also been satisfied.

One other note can be added to the above research work: the OSU Seafood Laboratory has just completed another test of treated and untreated shrimp, and I understand that the results confirm all of the previous information. Dr. Morrissey can provide you with more details on this. The final conclusion is that this application of phosphates can definitely be considered to be a processing aid, and does not require listing in the product's ingredient statement.

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