Job Aid #2: Hydrogen Peroxide Method

The Armour U.S. Patent 2,776,214 covers the use if the hydrogen peroxide and heat for the pasteurization of egg whites over a wide range of operating conditions. The process describes in this instruction is an embodiment of the over-all patent.
Improvements in the equipment and/or processing technology may result in changes in the process as described in this instruction while remaining within the scope of the patent.

I. The Nature of the Process:

The effectiveness of the Armour patented process for pasteurizing egg white results from the addition of hydrogen peroxide to the egg white to supplement the action of heat on microorganisms. Hydrogen peroxide has been used as a disinfectant for many years and has its own effect on microorganisms, but used in conjunction with a pasteurizing temperature, its effectiveness is greatly increased, particularity in the case of coliform organisms including *Salmonellae*. In the Armour process, the addition of hydrogen peroxide makes it possible to reduce the holding temperature of pasteurization far below the point of heat damage to the functional properties of egg whites, and, in fact, so low that there is no build-up of coagulated protein on the pasteurizer plates.

Hydrogen peroxide is perhaps the most ideal compound, which could be selected to be used in pasteurization because it is readily decomposed after it is used and the end products of the decomposition are water and oxygen gas. The decomposition is as follows:

$$2H_2O_2 \xrightarrow{\text{catalase}} 2H_2O + O_2$$

Hydrogen peroxide   Enzyme   Water   Oxygen

Catalase, a natural enzyme that causes the decomposition of hydrogen peroxide through the reaction indicated above, is present in a great variety of biological tissues. There is sufficient catalase activity in egg white to decompose far more hydrogen peroxide than is used in the process. Thus, it becomes necessary to reduce the catalase activity of the egg white to prevent decomposition of peroxide and subsequent lowering of the effectiveness of the process. Fortunately, this can be accomplished because the catalase activity is markedly reduced by heat. In the Armour process, the egg white is heated and held for a period of time before the addition of peroxide. The resulting reduction of catalase activity makes possible the use of low levels of peroxide to be effective during the pasteurization process.

The suggested Armour process is very simply accomplished as a smooth flowing continuous operation in the standard pasteurizing equipment of heating plates and holding tubes already used for heat pasteurizing whole egg and yolk. The liquid is heated in the plate and sent through the holding tubes. At the point in the holding tube, where the egg white has been held long enough to sufficiently inactivate the catalase activity, the peroxide is injected into the egg stream continuously at a rate sufficient to give the desired concentration of peroxide, and the flow continued for the balance of the holding time. The liquid then goes to the regeneration and cooling plates, as usual. This whole phase of the process is accomplished in a total holding time of 3 ½ minutes, (which is the same for the classical heat pasteurization of whole egg and yolk). After heating the egg white and pasteurizing with the added hydrogen peroxide, catalase is added to the cooled, peroxide containing egg liquid. The peroxide is decomposed and the liquid is ready for packaging.

II. <u>Operational Procedures for Armour Hydrogen Peroxide Pasteurization Process</u>

A. Basic Equipment and Description of Process:

The basic equipment used for the Armour process is the standard plate pasteurizer and holding tube equipment for pasteurizing whole egg and yolk where the holding tubes are set up for a 3 ½ minute holding period.

The egg white is heated to 125 – 127 ºF in the plates and pumped into the holding tubes. After 1 ½ minutes of holding, a 10% hydrogen peroxide solution is metered into the egg white stream to give a concentration of 0.05% to 0.10% peroxide. The holding at 125 ºF is then continued for the remaining 2 minutes. At the end of the 3 ½ minutes period in the holding tube, the liquid is cooled in the plates as usual. To the effluent pasteurized, cooled egg white, catalase is added at the rate of 2 to 4 ml per 1,000 lbs of egg white. After the catalase has destroyed the residual peroxide, the eggs are packaged.

B. Modifications and Additional Equipment Necessary to Implement the Armour Procedure:

In order to pasteurize egg white by the Armour method, two basic modifications must be made in the standard pasteurization equipment, these modifications are as follows:

1. <u>Reset the flow diversion valve:</u> the divert temperature should be set at 125 ºF and the adjustment of this instrument should be done by a properly trained person because of the delicate nature of the control mechanism. If the pasteurizer is to be used for yolk-containing products, which require a higher

temperature, an instrument may be purchased which will allow alternation between 125 ºF and higher divert temperatures by the flip of a switch.

2. Installation of peroxide injector and accompanying equipment: essentially, three items are required to accomplish the addition of peroxide to the egg white, they are as follows:

   a. *Peroxide injector elbow* - this is the fitting through which the stream of hydrogen peroxide solution is injected onto the egg white stream in the holding tubes. The injector itself consists of a sanitary elbow (or identical to) from those on the holding tubes into which a length of ¼" SS tubing has been welded or otherwise inserted. The peroxide tube should be inserted so that approximately 8" of the tube extends upward into the holding tube. The end of the peroxide tube is closed and several small holes drilled into the lateral surface near the end of the tube. This helps disperse the peroxide throughout the liquid egg. The elbow is installed so that the peroxide enters in the opposite direction of the flow of the egg.

   b. *Flow meter* - this device is installed in the peroxide injection linr to give a continuous visual indication of the flow of peroxide and the rate at which it is being injected. The rate of liquid flowing through the rotameter is indicated by the position of a ball float in the calibrated tube. A chart is furnished with each rotameter, which gives the setting required for the appropriate peroxide rate. The peroxide passes through the meter and into the product by way of the injector.

   c. *Alarm* - the alarm system is a device, which provides sensitive control of peroxide flow by the use of a sensing coil encircling the glass tube of the rotameter. As the metallic float passes into the electrical field of the coil, the alarm is actuated indicating minimum peroxide flow.

   d. *Pressure tank or proportioning pump* - this is the means of forcing the peroxide solution into the holding tube against the back pressure of the egg white at that point in the tubes. In the pressure tank system, compressed air is used to move the peroxide, but of necessity a compressed air source must be available of pressure 10 to 15 lbs. greater than that in the holding tubes. In the proportioning pump approach (used where compressed air is not available), the pump must be a positive pressure type and adjustable over a range of flow rates.

      i. Pressure Tank Systems – this employs two stainless steel pressure tanks capable of holding about 70 lbs. of solution and air pressure of 100 psi. An hour's supply of peroxide solution is placed in one tank, compressed air applied, and the tank connected to the system with its quick-lock hose connection. The second tank is prepared in advanced of need and the connections switched at the appropriate time.

ii. Proportioning Pump System – in this system, pressure tanks for the peroxide are not required but a stainless steel reservoir tank is necessary to feed the 10% peroxide solution to the pump.

C. *Operational Sequence:*

Some of the items mentioned below are appropriate to any pasteurizing operation, but are repeated here in sequence:

1. Timing pump is calibrated and set to assure proper egg rate.
2. With rate established, holding tubes are checked to assure 3.5 minutes total holding time.
3. All thermometers and controls are calibrated to assure proper temperature recording and control.
4. The elbow, which represents 1-1/2 minutes holding time is located and replaced with the peroxide injector elbow.
5. Peroxide preparation: A 10% hydrogen peroxide solution is prepared by dilution of the 30 or 35% peroxide. The 10% peroxide is placed in the SS pressure tank or reservoir tank for the peroxide pump. If the pressure tanks are used, compressed air is applied to the tank at a pressure sufficient to force the peroxide into the egg white. The peroxide supply is connected thru the flow meter to the peroxide injector elbow.
6. Start pasteurizer on water: The pasteurizer should be brought up to temperature sufficient to maintain an egg temperature of 125-127ºF. When the water temperature reaches 127 º F, the peroxide may be started by adjusting the valve on the flow meter or the pump to feed the required amount of peroxide based upon the egg pasteurization rate.
7. Activate the alarm system: The alarm system should be activated at this point to insure the detection of any low peroxide addition.
8. Egg white pasteurization: As soon as peroxide is detected in the water at the outlet of the pasteurizer, egg white may be turned into the system. (Peroxide may be detected by using Miles Chemical Co. Peroxystyx.)
9. Removal of peroxide after pasteurization: Approximately 2 ml of catalase per 1000 lbs of egg white is added to the egg white vat. This is done by adding the catalase as soon as the egg starts to enter the collection vat; adding the catalase at this point allows the enzyme to act on the peroxide while the tank is filling.

III. <u>Prevention of Recontamination:</u>

With the advent of pasteurization in the egg liquid field due to regulatory requirements, the emphasis on bacteria in egg meat has passed from the concern with numbers to concern for the presences of specific organisms, namely, *Salmonellae*, in any determinable number. This means that much greater concern must be taken to prevent contamination of egg liquids after pasteurization.

There is very little purpose in putting forth the additional effort and expense to pasteurize if the fruits may be vitiated by carelessness in operation, which may result in seizure or the necessity to reprocess product, which is already in the freezer.

Some of the sources of contamination, which are often overlooked, are:

1. Airborne contamination – This may be in the form of dust borne organisms being stirred up from a dry floor, which is a traffic pattern for shell eggs. It may also be moisture-droplet borne from an area where shell eggs are being spray washed or rinsed.
2. Equipment – Improper sanitizing of lines, pumps, etc. Using common lines to run raw and treated liquid alternately.
3. Containers – Egg cans, tank trucks that may have been cleaned but are then exposed to contamination after washing and before or during filling.

While the antidote for all these problems can be said to consist of common sense, good housekeeping and sanitary practices, one basic thing should not be over-looked: attention should be given to controlling cross-traffic between raw material, raw product, and pasteurized product. This cross-traffic to be concerned with includes those of: (1) personnel, (2) product, (3) containers and, (4) air, and could best be eliminated by having the pasteurized liquid area separated from the areas in which raw material and raw product are handled.

1. <u>People</u> who work in the shell egg and egg breaking areas should not promiscuously pass through the area in which the pasteurized liquids are canned or otherwise filled.
2. <u>Raw liquid</u> should <u>never</u> be handled in the same pipelines as the pasteurized product. Any cross-connection of lines should be eliminated.
3. <u>The cans</u> used for freezing eggs must necessarily be properly washed and sanitized. However, care must be exercised in handling from the washing to filling areas to preclude recontamination of the cans.
4. The pasteurized liquid area should be maintained under positive pressure (using filtered air) to prevent the entrance of any of the airborne contamination mentioned above. If air is permitted to flow from the other operational areas over the pasteurized product area, there is a possibility that contamination will occur.

The foregoing remarks are applicable to all egg pasteurizing operations, whatever the process or type of product.

The efficacy of the treatment in any well-operated and controlled process should not be put into question by the sporadic occurrence of *Salmonellae* in the treated product as long as the potential recontamination problem is present.

The efficacy of the Armour process for egg white has been demonstrated for numbers of *Salmonellae* far in excess of those that could ever be encountered in good quality raw material.

IV. Special Suggestions:

A. Selection of Canning Vats (when packing frozen egg):

Experience has shown that one of the most satisfactory arrangements for canning vats consists of two tanks, each of which will hold a one-hour pasteurization run. This arrangement allows enough time for the catalase to remove most of the residual peroxide while the vat is filling. Consequently, the amount of time required for the peroxide removal after the vat is full is quite short. While the first tank is being voided of peroxide and canned, the second vat may be filled. This procedure lends itself well to a continuous operation when pasteurization and canning occur simultaneously.

An alternate method is to have one tank capable of holding a complete pasteurization run. With this type of operation, the length of time for peroxide removal is extended and the liquid held at 35ºF ± 2ºF. As noted in the section on foam development, this procedure (colder temperature and longer peroxide removal time) causes less foam development. This procedure does not permit canning and white pasteurization to occur simultaneously.

B. Causes of Foam Production:

Normal precautions should be taken to prevent foaming as in all other egg white operations. That is, the whites should not be allowed to fall long distances into the vats and all fittings and pumps should be tight to prevent incorporation of air. The amount of foam created by this process varies according to several factors, they are as follows:

1. Temperature: Higher egg temperatures during the peroxide removal step result in greater volume of foam. The breakdown of peroxide by catalase is an enzymatic reaction (formula in Part I) and is affected by temperature. As the temperature of the egg is increased, the rate of reaction increases and the oxygen gas is produced more rapidly. This gas becomes trapped in the egg white and produces foam. If the gas is produced slowly, the foam build-up is less. Therefore, it is most desirable to let the peroxide removal take place during a more extended period at a lower temperature.

2. Amount of enzyme used: The amount of catalase enzyme used has a definite effect on the rate of peroxide removal. The greater the amount of catalase,

the fast the peroxide removal proceeds. Again, the more rapid peroxide removal results in greater foam production.

C. Hydrogen Peroxide:

Hydrogen peroxide is procured as 30 or 35% strength, depending upon the supplier used.

There are several precautions that should be observed when working with concentrated hydrogen peroxide. The 30 or 35% peroxide is a very powerful oxidant and should be carefully handled according to <u>all precautions</u> given by the supplier on the container. The purchase of a peroxide pump from the supplier will make handling of this material much easier.

In addition, extreme care must be taken to not contaminate the peroxide; its decomposition (with consequent release of large volumes of oxygen gas and quantities of heat) is brought about by dust, organic matter and contact with metals other than stainless steel and aluminum. Contact with iron, copper, brass, monel, etc. must be strictly avoided.

The hydrogen peroxide, as mentioned earlier, will be either 30% or 35%; this should be carefully noted before preparing the 10% solution by dilution.

If 30% is used, 10 lbs. of peroxide with 20 lbs. of water will give the 10% solution; if 35% is used, 10 lbs. of peroxide with 25 lbs. of water will give the 10% solution.

The water used for diluting the peroxide should be demineralized or desterilized to prevent the decomposition mentioned above. In some areas, tap water might be suitable for this purpose, but in most cases, its use will result in decomposition of the peroxide. If many bubbles (of oxygen) appear in the tube of the rotameter (making the ball float bounce), it will be difficult to control the rate of injection. If this occurs, a purer source of water must be used.

It is a good idea to make up the 10% peroxide solution at one or two hour intervals to minimize decomposition. The 10% solution must not be held overnight.

D. Rotameter:

The selection of the proper rotameter tube and float depends upon the rate of peroxide usage for a particular operation. When ordering the rotameter, the maximum and minimum rate of 10% peroxide usage anticipated should be specified in pounds per hour. Given the two figures, the rotameter supplier can recommend the appropriate tube and float for the range of volume given.

The amount of peroxide solution (10% concentration) which will be used to achieve the minimal concentration in the whites of 0.05% is 5 pounds per thousand pounds of whites. Thus, if the pasteurizer rate is to be 6000 lbs per hour, the use of peroxide solution will be:

5 lbs/1000 lbs x 6000 lbs/hr = 30 lbs of 10% solution <u>per hour.</u>

E. Reagents

1. <u>Hydrogen Peroxide:</u> The major producers of <u>food grade</u> hydrogen peroxide include:

   Du Pont
   Food Machinery Corp. (Becco Chemical Div.)
   Allied Chemical & Dye (Solvay Process Div.)

   In addition, a major distributor with many warehousing points is:

   McKesson & Robbins

   Be sure to specify "Food Grade" and either 30% or 35% (depends on supplier).

2. <u>Catalase</u>:

   Reheis Chemical Company
   Division of Armour
   Pharmaceutical Co.
   P.O. Box 511
   Kankakee, Illinois 60901
   (Mr. E. A. West)
   Telephone: (815) 932 – 6771

   Available in 1-liter (1,000 ml.) bottles

Schematic Diagram of Process