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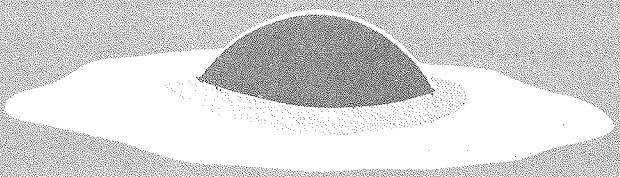
# QUALITY CONTROL of eggs and egg products



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Issued May 1968, 2000

# Quality Control of Eggs and Egg Products

By

G. W. Froning, Associate Professor, Poultry Science
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## INTRODUCTION

Quality control of food products has become essential to meet specifications demanded by the market system, the consumer and the public welfare. This publication reviews factors which must be considered for quality control of shell eggs and egg products.

Quality maintenance is important at all points in the handling and marketing sequence. This essentially means that the producer, processor and retailer must all be knowledgeable and practice desirable egg handling methods to achieve top quality maintenance.

The realization of the impact of any one segment of the industry is not always evident. Nevertheless, one poor practice, such as poor gathering or cooling, may ultimately lower the quality of the egg entering marketing channels.

Once damage is done to a food product the mistake is difficult or impossible to rectify. Therefore, quality control of eggs and egg products requires a team effort.

A quality control program consists of following practices which combine to provide eggs and egg products of needed quality specifications.

It is necessary to understand the properties of eggs and the factors which influence them. There is no one quality control program to fit each need but rather one must define what specifications are required or desired and then build the program.

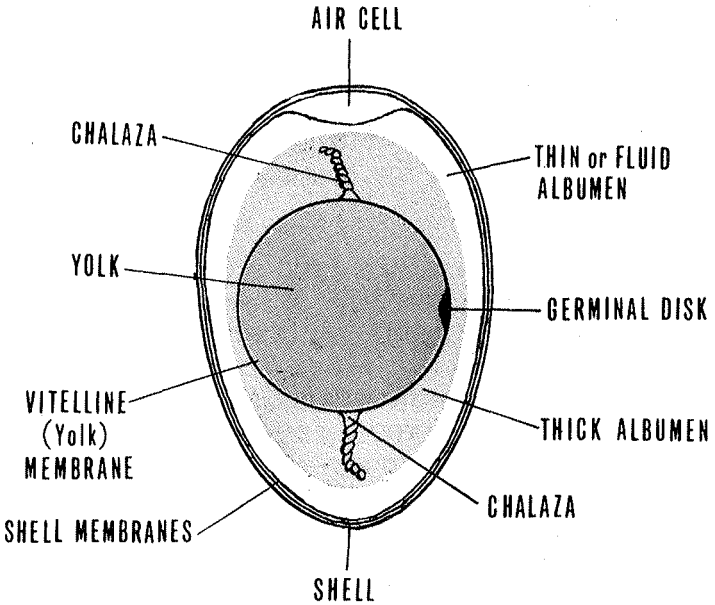
Quality of shell eggs and egg products includes: exterior and interior quality of shell eggs, freedom from foreign material (including microbial and chemical materials), color of yolks and yolk materials and functional properties of egg products.

Quality specifications will be increasingly regulated on eggs and the success of future programs will depend upon how well the individual organization follows quality control and remains competitive.

## PROPERTIES OF THE EGG

### Composition

The egg is one of nature's most complete foods. Obviously its original purpose was to be able to totally support life--the embryo. Proteins in the egg are among the best in biological value. In addition, the egg is a capsule of other essential nutrients including vitamins, essential fatty acids and minerals.




**The Egg and Its Parts**

The average egg weighs about 2 ounces or 56 grams. The gross composition includes the shell and shell membranes (11%), the white (58%) and the yolk (31%). The percentage composition of the edible part of the egg is:

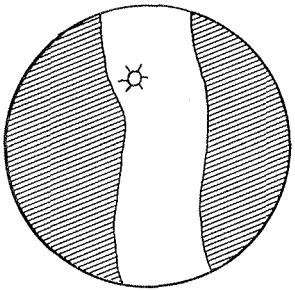
| | Whole egg % | White % | Yolk % |
|---|---|---|---|
| Water | 73.7 | 87.8 | 49.0 |
| Protein | 13.4 | 10.0 | 16.7 |
| Fat | 10.5 | .05 | 31.6 |
| Ash | 1.0 | .82 | 1.5 |

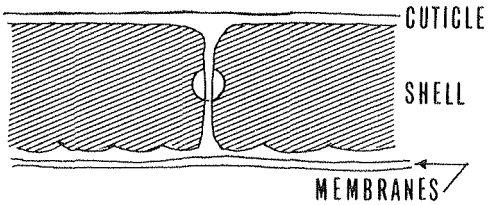
Compositional changes during storage are mainly due to loss of water. As the egg is stored, the percentage of solids in the white increases because of moisture loss through the shell and into the yolk. The yolk decreases in percentage of solids with storage because of the dilution effect of water migration from the white into the yolk.

Further changes noted during storage are the increased thinning of the thick white because of the modification of certain proteins in the white. Also the yolk becomes enlarged and the vitelline membrane surrounding the yolk weakens. These changes can be slowed down using proper storage conditions. Although there are physical and chemical changes occurring in the egg during these processes there are no great changes in the egg's nutritive value. A factor which must be recognized, however, is that during this breakdown process the egg is subject to flavor changes that can be undesirable.

## Bacterial Barriers

The egg has numerous bacterial defenses within it which help inhibit microbial spoilage. The shell is a relatively minor protective aid since numerous pores act as passages for invading bacteria. After passing through the shell, organisms do, however, meet considerable resistance from shell membranes.






Sketch of egg shell with one of the 6-8000 pores. Inset shows bacteria in a pore, both drawn to same scale.

If bacteria reach the interior of the egg, bacterial growth is resisted somewhat in the albumen. The proteins, lysozyme and conalbumin, are particularly instrumental in bacterial inhibition. Lysozyme causes lysing (rupturing) of selected bacterial cells while conalbumin binds iron, thereby making this mineral unavailable to bacteria which may require it for growth.

Spoilage problems may arise if eggs are washed in water containing high iron content (above 10 p.p.m.) since conalbumin can bind only so much iron. Iron in water is available to bacteria when conalbumin has bound its maximum. Protection in the yolk from bacteria is virtually nonexistent since the yolk offers an excellent media for their growth.

Although the egg contains some barriers to excessive bacterial growth, it can be overwhelmed and sanitary handling is very much needed in all phases of egg marketing.

## PRODUCER'S AND SHELL EGG PROCESSOR'S RESPONSIBILITY FOR QUALITY CONTROL

### Gathering

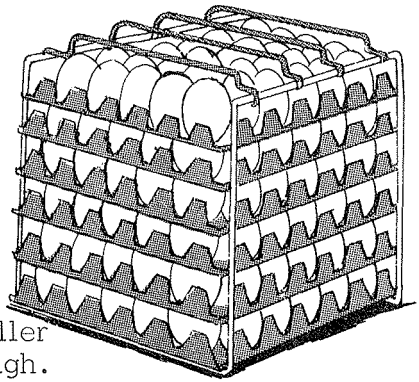
Quality control starts when the egg is laid. It is essential that the egg be moved into the processing area as soon after laying as possible. Ammonia fumes and high temperatures often encountered in the hen house will greatly speed-up egg deterioration.

Eggs should be gathered at least 3 times a day. During hot summer months increase the number of gatherings to at least 5 times to aid in retaining the highest possible quality for shell egg marketing.

If automatic egg gathering equipment is used, it is imperative that the producer keep it properly adjusted. Breakage may increase to objectionable levels if this is neglected.

Gathering eggs by hand may also lead to breakage problems. Careless handling by one operator may significantly reduce your profits and make the egg prone to microbial contamination through checked eggs. Personnel should be thoroughly instructed as to proper handling methods.

Placing gathered eggs onto clean filler flats is recommended. These eggs then may be conveniently moved onto in-line equipment after pre-cooling is accomplished. To reduce breakage, do not stack filler flats more than six high.



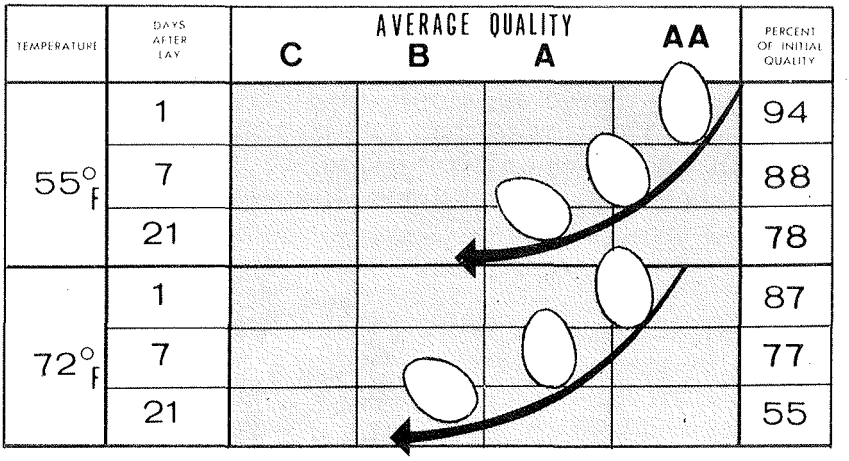
Eggs should be gathered on filler flats and stacked not over six high.

## Pre-Cooling and Storage

Bacterial growth and chemical reactions are greatly increased by higher temperatures. The freshly laid egg has a temperature over 100°F. The thick albumen thins rapidly when storage temperature is above 70°F.

Therefore, it is imperative that the heat in the egg be removed as soon as possible to reduce the rate of egg white deterioration and check microbial growth. Casing eggs without pre-cooling is an unsatisfactory practice since eggs in the center of the case will remain warm for some time, thereby creating an excellent environment for quality deterioration and bacterial buildup and thus increasing the possibility of egg spoilage.

Humidity is another important consideration with respect to egg storage. Water loss from the egg will cause a subsequent increase in air cell size. Moisture content of packaging materials (cases and filler flats) depends on the relative humidity. If these materials are too dry, they may act as a sponge and absorb moisture from the egg. Cases and filler flats should be "pre-conditioned" in the cooler before use.




The effect of temperature causing the loss of initial quality in eggs.

It is recommended that eggs be stored on-farm in "pre-conditioned" flats and cases at a temperature of 50 to 55°F and a relative humidity of 75 to 80%. This relative humidity level is high enough to retard water loss and low enough to prevent development of molds.

The storage area should be free of foods that may impart odors or off-flavors to eggs. Onions, apples, etc., stored near eggs may impart off-flavors to eggs.

## Packing

Clean packaging materials are a must in any quality control program. Egg contents and fecal debris on old filler flats and cases create an excellent media for bacterial growth and contaminate eggs packed upon them later.

This becomes extremely critical to our control of *Salmonellae* contamination. These materials need also to be structurally sound and provide protection to the egg during

shipping and storage. Studies indicate egg breakage increases after the second time you use cases and filler flats compared to new materials.

## Oiling

Oiling will help prevent loss of moisture and carbon dioxide ($CO_2$) from the egg and retard egg quality deterioration. This practice is advisable for shell egg marketing programs. As the egg loses $CO_2$, there is a corresponding increase in alkalinity (pH) of egg contents. Increased alkalinity speeds up egg white thinning by affecting certain protein reactions.

Spray-oiling eggs on filler flats at the time of gathering is the preferred technique. A special lightweight mineral oil is recommended. Application may be implemented effectively using a hand-pump type sprayer or other suitable commercial sprayer. Apply enough oil to cause formation of a droplet on the small end of the egg.

## Salmonellae Control

Over 900 species of Salmonellae are known to exist. This organism will produce food-borne infections in humans particularly when contaminated food is prepared and held in such a manner as to allow bacteria to increase to large numbers.

Food products prepared at large picnics or other gatherings may present a problem particularly if the food is held at high temperatures for extended periods of time.

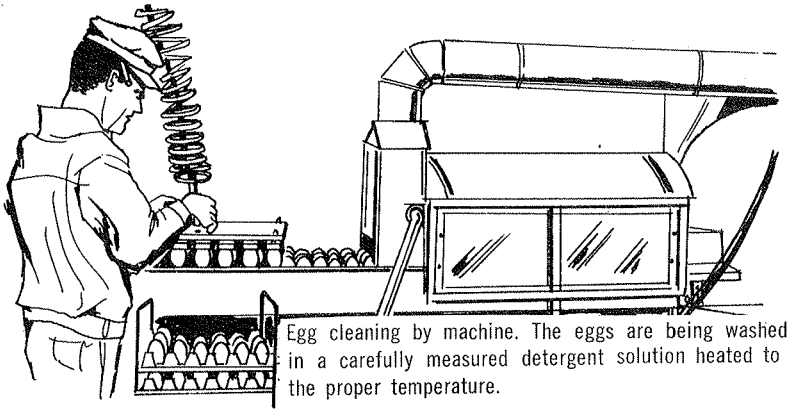
The producer may minimize Salmonellae contamination by rigid sanitary control at the farm level. Frequent egg gathering to reduce soiled eggs, feeding uncontaminated feeds, elimination of rodents (disease carriers), use of proper egg washing procedures, reduction of cracked eggs, use of clean filler flats and cases, and adequate cooling of the egg will greatly aid marketing of Salmonellae-free eggs.

Salmonellae are common to all animal as well as human food products so this problem must be faced with positive control measures.

## Washing

Wash eggs soon after gathering to facilitate easy removal of adhering materials, reduce microbial contamination and decrease the incident of cracks caused by cold eggs in contact with hot water. Excessively dirty eggs should not be washed since they are virtually impossible to clean and may act as a source of bacterial contamination. Since these eggs are potentially unmarketable, it is better to prevent excessively dirty eggs by incorporating good gathering procedures with clean management in the laying house.

It is best to avoid using wash water with more than 2 p.p.m. iron present. The keeping quality may be impaired because of increased bacterial spoilage (for reasons discussed earlier).



Egg cleaning by machine. The eggs are being washed in a carefully measured detergent solution heated to the proper temperature.

Maintain water temperature rigidly at 115-120°F. The higher the temperature the more bacteria will be destroyed. However, avoid excessively high water temperatures since egg albumen will coagulate around 140°F.

Wash water should always be warmer than the egg to create a positive pressure to prevent suction of any contamination into the egg.

Approved egg detergent-sanitizers should be used which do not contain any odor producing agents. The detergent used should have good wetting ability as well as good emulsifying properties and low foaming power. Detergents only have ability to remove dirt from the egg shell and are not bacterial inhibitors.

Sanitizers inhibit and kill microbial populations. Quaternary ammonium compounds are most often used because of their excellent germicidal power, wetting ability and emulsifying characteristics.

Chlorine containing compounds such as sodium hypochlorite are used but it has limited germicidal value.

Germicidal capabilities of the hypochlorites are rendered useless in the presence of organic matter and high temperatures greatly reduce the effectiveness.

Hypochlorites are most effective when used as a rinse after the eggs have been properly washed using a detergent. Excessive levels of free chlorine (70 p.p.m.) in either the washing or rinsing solutions have been known to cause a brown discoloration of an egg's surface several hours after the cleaning process.

Whatever sanitizer is used, rinse eggs in a warm sanitizer solution after washing and dry them rapidly. This leaves a protective coating of sanitizer on the shell surface.

Washed eggs should be completely dry before packing. Moisture on the shell surface makes the shell surface very conducive to bacterial growth and entry into the egg.

## In-Plant Washing

In-plant washing of eggs is common. On-farm washing has been abused by some and many processors prefer to delay cleaning to assure proper washing. If this system is to be effective, it is imperative that a minimum of dirty eggs are produced.

Eggs to be washed in the plant should be moved to the plant at least two or three times a week and preferably daily. The longer dirt is left on the egg the more chance for bacterial contamination.

Oil coating of dirty eggs is practiced by some to keep adhering dirt loose as well as to provide some degree of

sealing the eggs against $CO_2$ loss. This method is highly questionable, however, since oil may act as a vehicle for bacterial invasion. It is best to oil after the egg is clean.

Advocates of in-plant washing emphasize that washing procedures are better controlled in a central location. In-plant cleaning allows use of stronger detergents and hotter temperatures since better control of the cleaning operation is possible. Rapid drying of eggs in the plant is a necessity to assure continuous processing operations.

## Pesticides

Production of eggs free of pesticides requires that the producer keep constant vigilance on the use of pesticides around the premises. Carelessness may allow pesticide residues to build up to unacceptable contamination levels in eggs and birds.

There are three general types of pesticides used--chlorinated hydrocarbons, organic phosphates and carbamates.

The organic phosphates and carbamates are not a great problem since their residues readily break down to harmless end products.

On the other hand, chlorinated hydrocarbons break down slowly and persist for long periods of time and occasionally the degradation products are also harmful.

Examples of chlorinated hydrocarbons are DDT, BHC, lindane, chlordane, dieldrin, aldrin, rhothane, toxaphene, Perthane, methoxychlor, heptachlor and endrin.

Residues caused by feed are less of a problem in poultry and eggs than in dairy products because poultry feed is composed predominantly of grain. Nevertheless, there are hazards such as contaminated dehydrated alfalfa meal. Direct application of pesticides to the alfalfa crop can cause contamination. Drift from spraying fields or range may be a potential hazard.

Research has shown that residues build up in eggs and body fat when birds are put in houses previously sprayed with DDT.

Pesticide control of eggs and egg products is a necessity.

Health regulatory agencies as well as processors will not tolerate residues in egg products and many routinely check pesticide levels of incoming liquid eggs.

Unless producers use extreme care in handling pesticides they may find their eggs contaminated with no market available and may be unable to dispose of their hens.

Producers should follow manufacturers' recommendations when applying sprays.

Particular care must be taken when spraying fields adjacent to poultry housing. Chlorinated hydrocarbons should not be used around the poultry farm.

In addition, the American Poultry and Hatchery News (November, 1964) indicates that Delnav Guthion, methyl parathion, Phosdrin and TEPP should not be used.

## RESPONSIBILITIES OF EGG PRODUCTS' PROCESSORS FOR QUALITY CONTROL

### Product Specifications

Any final egg product can be no better than the individual ingredients incorporated into it. Controlled ingredient composition will give some assurance that the product will be uniform from batch to batch.

The processor can vary ingredients to conform to formulation demands but this is costly. Therefore, ingredient specification (bacteriological and chemical composition) should be designated and your supplier should adhere to these as closely as possible.

If you are supplying egg products to other food processors, it is important that you know their requirements. The functions required may dictate the needs of the food manufacturer.

Cake mix manufacturers need egg products with different specifications than those of mayonnaise processors.

Mayonnaise manufacturers usually require salted yolk products prepared to their specifications whereas an angel food cake mix manufacturer may require egg albumen with low yolk fat content.

## Sanitation

Sanitation is not to be disregarded for foods that receive pasteurization treatment. Pasteurization cannot be looked upon as a cure-all for poor sanitary practices. High bacterial count in the raw product is not desirable even though good pasteurization can be obtained.

Original chemical action and by-products of bacteria can influence quality even though the bacteria are killed later. Dirty checked eggs should not be salvaged.

Buildup of contamination on equipment should be minimized. Egg-washing equipment must be adjusted properly and kept clean. Conveyor belts may become contaminated and thus need continuous cleaning during processing operations.

Complete cleaning and sanitizing should be accomplished every 4 hours. Breaking machines and utensils should be inspected periodically and maintained in a sanitary manner.

Rotation with clean utensils every 2 1/2 hours should become a routine practice.

Pasteurization equipment needs proper cleaning before use. Give particular emphasis to pumps and valves where bacterial loads may accumulate.

Flush HTST (high temperature short time) equipment with tap water after product flow has ceased.

CIP (clean-in-place) acid cleaning at 165°-170°F should be accomplished for 20 to 30 minutes followed by a tap water rinse, an alkali solution at 165°-170°F (20-30 minutes) and finally another tap water rinse.

Flush churns, draw-off tanks and other liquid holding equipment every 4 hours. Such liquid handling equipment

must be dismantled, cleaned and sanitized after each shift unless acceptable clean-in-place methods are applicable.

Clean and sanitize mechanical egg breaking equipment as often as necessary to keep it sanitary. In addition, thoroughly clean and sanitize automatic egg breakers every 4 hours and at the end of the shift.

Pasteurization

Whole eggs normally are pasteurized using a temperature of 140° to 142°F for 3 1/2 minutes while egg yolk is processed at 144° to 146°F for 3 to 3 1/2 minutes.

A method developed in Britain uses a temperature of 148°F for 2 1/2 minutes for both whole eggs and yolks. This higher temperature does cause some damage to functional properties.

Egg white solids may be pasteurized by application of a dry heat treatment to the powder. This treatment generally involves holding the powder at 128° to 130°F for 7 to 10 days.

Moisture content of the dry product should be about 6 to 7% to get a good bacterial kill and to prevent damage to the product.

Another method of pasteurization has been developed by the USDA. This method requires the adjustment of pH to 6.8 to 7.0 and addition of an aluminum salt before heat treatment at 140° to 142°F for 3 1/2 minutes.

Armour and Co. has patented a method which uses a temperature of 125° to 130°F for 3 1/2 to 4 minutes with addition of 1 to 1.5% hydrogen peroxide halfway through the holding time. Catalase is added after the heat treatment to remove residual hydrogen peroxide.

Whatever pasteurization procedure is used, the processor must rigidly follow recommendations. Temperature-time control and chemicals added should be monitored closely to be sure that optimum effect of the pasteurization is realized.

# QUALITY CONTROL TESTS

## Producer and Shell-Egg Processor

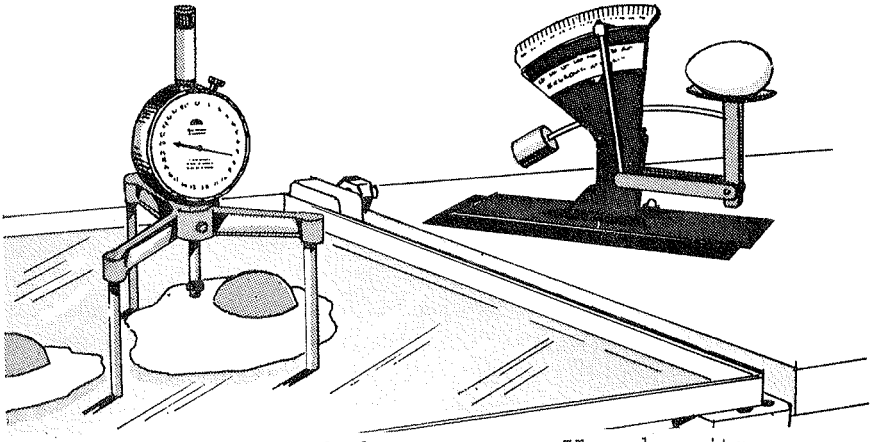
Quality control steps at the producer-shell egg processor level may be simple but they may affect the ultimate egg quality. It may be well to work out a routine checklist (Table 1) of the points discussed to be monitored daily.

Check wash water temperatures periodically to see that no bad changes occur. This should be done at least twice a day or whenever it appears the temperature is out of control. Replenishment of wash water must be monitored closely.

Watch records on the number of cracked or broken eggs closely. If this number increases, it may be necessary to adjust egg handling equipment or to check your employees.

Monitor temperature and humidity in the storage room periodically to make sure storage conditions are satisfactory.

Check quality of eggs from time to time. It may be advisable to have a routine breakout quality determination (Haugh unit) of a representative sampling twice a month. This may give a clue to something wrong further along the egg handling sequence.



Equipment needed to measure Haugh units.

Table 1. - Quality Control Checklist for Producer

1. Washing:

   (a) Water temperature. ----------
   (b) Are eggs properly cleaned? ----------
   (c) Are eggs dry as they are packed? ----------
   (d) Is detergent sanitizer being used at right concentration? ----------

2. Storage:

   (a) Temperature, °F. ----------
   (b) Humidity, % RH. ----------
   (c) Are there any unusual odors? ----------
   (d) Is the storage area clean? ----------

3. Ration Changes:

   (a) Date of change. ----------
   (b) Nature of change. ----------

4. Housing and management:

   (a) Odors (note abnormal levels of ammonia) ----------
   (b) Temperature ----------
   (c) Disease outbreaks (note date) ----------
   (d) Note any changes in gathering methods ----------

5. Comments:

Defects such as mottled yolks or thin shells may become a problem. If your personnel are observant, these problems may be caught and corrected before hurting your egg market. If some defect does occur, apply a systematic approach to the problem involving all segments of the operation including nutrition, management, egg handling and storage. It may be necessary to obtain additional advice from your county agent, extension poultry specialist or serviceman.

Check automatic egg weighing equipment at the beginning of each day and periodically during the day. This type of equipment should be kept clean and free of moisture to make sure electric contact points operate properly.

Where continuous in-line equipment utilizing flash candling through cartoning is involved, it is important that the personnel become thoroughly familiar with proper adjustments. Light intensity should be continually checked also. Improper adjustments may lead to unduly rough handling of eggs, thereby causing marketing problems.

Egg Products Processors

Most plants of any magnitude today have a small quality control laboratory to test raw product, ingredients and final products. Many laboratories are equipped to run such tests as solids, color, fat (monomolecular film test), functional tests, pesticide residues and various bacteriological tests (coliforms, total plate counts and Salmonellae). Smaller plants may not run all of these tests and of course some companies will have these tests run for them by a private laboratory.

It is becoming increasingly important that processors have a quality control laboratory. Tests are necessary on incoming ingredients to meet specifications.

Also, specifications of the final product dictate certain guidelines to stay within. If a laboratory facility is not within the plant area, it becomes difficult to do a good job of daily surveillance of raw product, ingredients, production line and final product.

Whatever size quality control section is involved, it is important that it have authority. Quality control should report to top management and be able to make changes on the production line when needed.

The quality control director should have a good working relationship with production and often much tact is needed to tell key production people to improve certain processing operations.

Table 2. - Quality Control Checklist for Shell Egg Processor

1. Candling:

(a) No. of cracks and broken eggs. ----------
(b) No. of blood or meat spots. ----------
(c) Other rejects. ----------
(d) Total eggs processed. ----------
(e) Is candler adjusted properly (light and conveyor adjustments)? ----------

2. Washing:

(a) Water temperature. ----------
(b) Are eggs properly cleaned? ----------
(c) Are eggs dry as they are packed? ----------
(d) Is detergent sanitizer being used at right concentration? ----------

3. Sizing and cartoning:

(a) Is weighing device adjusted properly? ----------
(b) Is cartoning machine adjusted correctly? ----------
(c) Is equipment clean; are controls kept free of moisture? ----------

4. Storage:

(a) Temperature, $^{o}F$. ----------
(b) Humidity, % RH. ----------
(c) Are there any unusual odors? ----------
(d) Is the storage area clean? ----------
(e) Is dry storage area clean and free of excess moisture? ----------

A system of sampling the daily production should be planned.

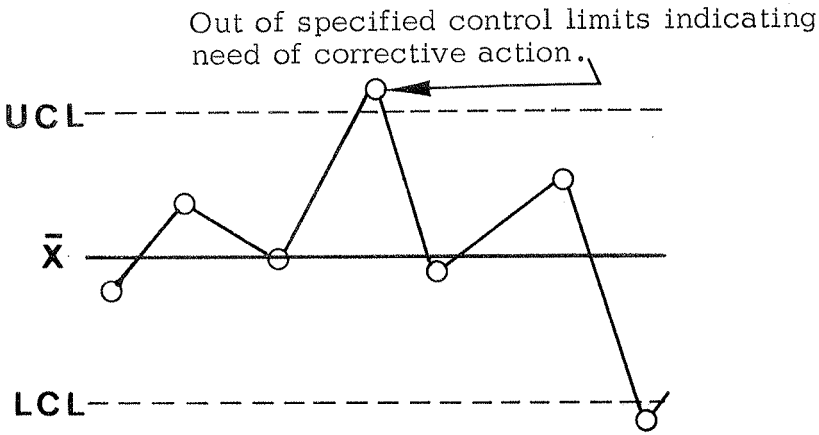
Statistical sampling procedures are often the answer; they can help prevent taking too few samples or too many samples.

Recording and summarization of results of quality control tests is another important consideration. Forms should include dates, point of sample collection, lot number and conditions that may affect sample on the day of collection such as temperature, humidity and line shutdowns.

Be sure adequate space is included on forms for data and that data get back to plant personnel most closely involved.

Quality control charts with upper and lower control limits offer an effective method of recording data. When the inspection data falls out of the control limits, personnel know corrective action is needed.

Control charts may be used for many phases of quality monitoring including fill control, color measurements, solids content, etc.




A quality control chart with upper (U.C.L.) and lower control limits (L.C.L.). Daily or periodical monitoring gives the processor trends for such phase as fill control, solids content etc.

## Egg Quality Trouble Shooting Chart

| Problem | Possible Cause | Corrective Action |
|---|---|---|
| Thin albumen | Poor storage conditions | Store at 55°F and 75-80% relative humidity. |
| | Disease (Bronchitis or Newcastle) | Recovery variable. If not too severe, quality may come back. Many times may have to sell flock. |
| | Genetic | Some hens consistently lay eggs of low albumen quality. |
| | Old hens | Replace flock. |
| | Infrequent gathering | Gather eggs 3 to 5 times daily depending on environmental temperature. |
| Thin shells | Nutrition | Check ration formulation to see that calcium, phosphorus and vitamin D are adequate. |
| | Disease (Bronchitis or Newcastle) | Recovery variable. If not too severe, quality may come back. Many times may have to sell flock. |
| | Hot weather | Keep birds as cool as possible. |
| | Old hens | Replace flock. |
| | Drugs | Certain drugs such as Arasan (a fungicide) may cause thin shells. |
| Excessive cracked eggs | Rough handling by personnel or poor equipment adjustment. | Check all segments of egg handling from point of gathering to packaging. |
| | Temperature differential-washing | Gradually warm eggs prior to entering washer. |

| Problem | Possible Cause | Corrective Action |
| --- | --- | --- |
| Mottled yolks | Nutrition or Drugs (Nicarbazin), cottonseed meal, raw soybean meal, antioxidants such as gallic and tannic acid, wormers such as dibutyltin dilaurate and piperazine. | Remove the drugs or feed ingredient from the diet. |
| | Genetics | Certain strains routinely lay eggs with more mottled yolks. Birds that consistently lay the eggs may require removal from the flock. |
| | Storage | Proper storage at 55°F and 70% relative humidity. Oiling may also help reduce incidence. |
| Platinum yolks | Intestinal microorganisms | Feed high levels of a broad-spectrum antibiotic for one week. |
| | Capillary worms | Feed high levels of vitamin A. |
| Shell mottling | Uneven distribution of moisture in shell. More severe in eggs from older hens. Genetics may be a factor. | Less of a problem if eggs are washed soon after laying and cooled immediately. Excessive humidity may be a factor. |
| Tremulous air cells | Rough handling | Check all segments of egg handling system. |
| | Disease (Bronchitis or Newcastle) | Await recovery from disease to ascertain if condition clears up. |
| Blood spots | Primarily hereditary but with some nutritional and environmental factors suggested. | Select lines with low incidence. |

| Problem | Possible Cause | Corrective Action |
| --- | --- | --- |
| Cloudy whites | Very fresh eggs or eggs with excess oil. One should not worry too much about this defect since it generally connotes freshness. | Spray oil rather than oil dip to allow some breathing through shell. |
| Poor peeling-hard boiled eggs | Extremely fresh eggs or eggs with excess oil. | Aging of the egg usually corrects this condition. |