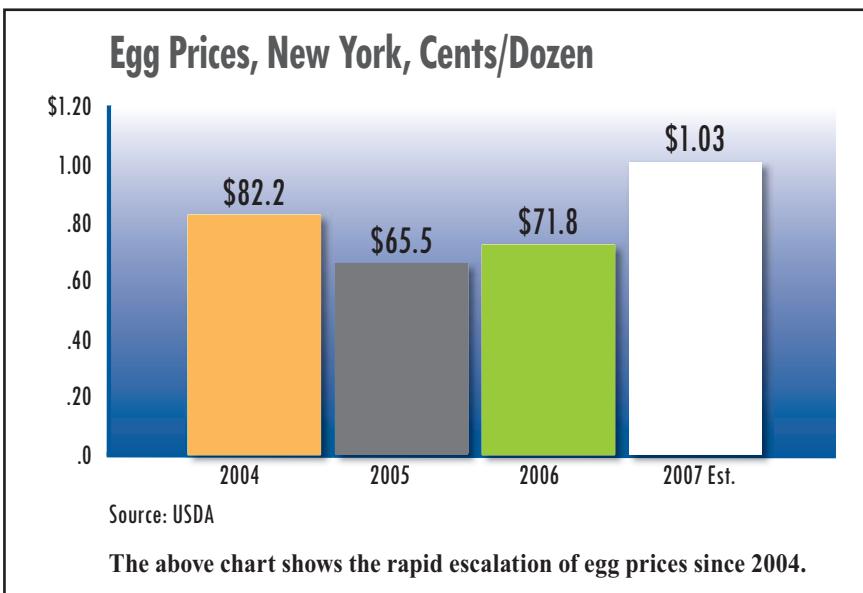


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2007 Egg Prices: One for the Record Books

Has the Industry Finally Learned How Not to Overproduce?



By Edward Clark, Editor

What a year for egg prices: they started the year strong, and didn't let up. For example, in late September, the Urner Barry large Midwest price quote was \$1.34 per dozen, almost double the 70 cent price of September 2006.

Will 2007 prices be the strongest ever? "I believe that will be the case," says Gene Gregory, president and CEO of United Egg Producers, Atlanta. Prices were also strong in 2003-04, but the run-up then started late and didn't run as long, he states.

"This will be a very good, profitable year, one of the best we've ever had, but I won't say most profitable because

grain prices have been so high," he adds, due to the ethanol boom.

In the past, producers have generally expanded when prices got high to curtail high prices, but not this time around. Reasons that prices have

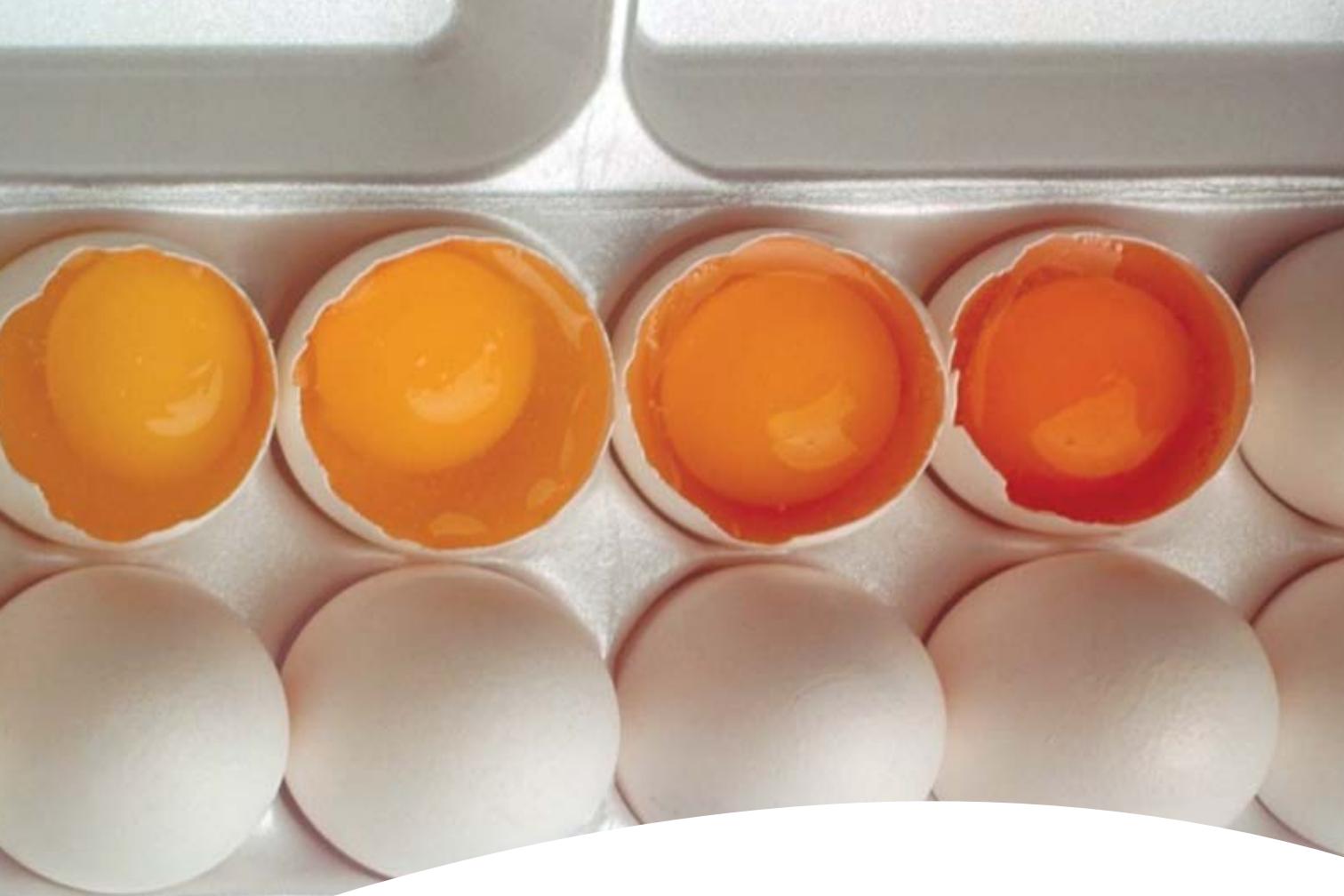
stayed so high during the summer, says Gregory, include:

- ▶ High costs of producing eggs due to high grain prices;
- ▶ Compliance with UEP's animal welfare program by more producers, which has kept numbers in check;
- ▶ This summer's heat, which has affected production and egg size;
- ▶ The considerably reduced inventory of dried eggs; and,
- ▶ Strong exports throughout 2007.

Gregory says that historically, when producers have a good, profitable year, they make long-term investments in new buildings, "but as a result of questions about bans on caged production on both federal and state levels, producers have delayed expansion decisions."

When asked by producers about the future of caged production, Gregory says he is "optimistic we will win the battle."

Looking at the rest of 2007, Gregory predicts that the fourth quarter "will be very profitable." Longer term, what concerns him is the percent increase in



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pullets hatched that could result in increases in flock numbers.

Steady Demand

Craig Willardson, president and CEO of Moark, LLC, Chesterfield, Mo., says that “discipline, balance, steady demand, and of course, the normal cycli-

es strong. One of the biggest that has kept supplies below year-earlier levels, he says, is the spike up in grain prices “that keeps our industry on edge.”

He also notes that the egg drier business has used up any inventory built up in 2005 and 2006. In addition, Seger says, the 100-degree days in July and August caused both high mortality and poor quality eggs.

Seger, chairman of United States Egg Marketers, also says that lower supplies occurred at a time when exports of both shell eggs and egg

products were increasing, particularly to Europe and the Mideast.

These exports were due in part to high global grain prices perhaps making it better to import the finished product rather than grain. He adds that domestic demand “is as strong as it’s ever been.” He also agrees that keeping up with animal welfare guidelines has kept supplies lower.

“We will increase supplies ever so slightly as we lead into 2008,” says Seger.

Paul Sauder, president of R.W. Sauder Inc., Lititz, Pa., says that one key factor keeping production in check in 2007 is that “we’ve been though two of the most difficult years from an economic standpoint, which has curtailed expansion.” He notes that demand for eggs is good, and that all foods have increased in price. Uncertainty on the animal welfare front “is a factor,” he adds. In terms of profitability, he says,

“You’d have to go to at least the 1980s to find a year as profitable.”

Industry Learning Not to Overproduce

Mark Oldenkamp, vice president, northwest operations for Valley Fresh Foods, Woodburn, Ore., says, “The industry is learning not to overproduce.” He adds that high feed costs have encouraged producers to eliminate marginal birds from production, and has discouraged expansion.

Oldenkamp adds that uncertainty about animal welfare has constrained producers from expanding. He says, however, “I don’t see cages going away and I don’t

▶ **Will prices be the strongest ever? “I believe that will be the case”**

—Gene Gregory

cal factors following a very poor market period starting in mid-2004” have helped keep prices strong in 2007.

The industry has been better able to manage its production and its inventories, he says, and trades of surplus product are finding the right market homes. In addition, Willardson says, customer demand has been surprisingly steady in spite of these high prices.

“It helps that all proteins and dairy products are commanding higher prices from consumers at the same time.” And, he adds that increasing worldwide demand has made a difference. In addition, “unbridled expansion has not been the norm this year with the uncertainty over animal welfare issues and hopefully, some long memories of the response in 2004.”

Grain Prices Keep Industry on Edge

Larry Seger, president of Wabash Valley Produce Inc., Dubois, Ind., says a combination of factors has kept prices

▶ **“We’ve been though two of the most difficult years from an economic standpoint, which has curtailed expansion”**

—Paul Sauder

think they should.” But that said, cage-free demand and production are increasing, he adds.

Unsettled Time

According to Marcus Rust, an owner of Rose Acre Farms, Seymour, Ind., producers are not expanding because they are facing such an unsettled time. For example, he says, animal rights activists with a vegan agenda are trying to put producers out of business and producers are battling avian influenza, salmonella, labor issues, and air quality issues, so expansion is not on the immediate radar. **EI**

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▶ New Study Says Eggs Protect Against Blindness

A six-year study has found that lutein and zeaxanthin, carotenoids found in eggs, spinach and other leafy green vegetables, offer some protection against blindness in the elderly, according to researchers. No clear associations with other nutrients were seen, including the vitamins C and E and beta-carotene, according to a Reuters article. The study was led by John Paul SanGiovanni of the National Eye Institute, one of the National Institutes of Health, in Maryland.

The study asked about the dietary habits of 4,519 people aged 60 to 80. The article says that those in the top fifth of dietary consumption of foods containing lutein and zeaxanthin had 35 percent less chance of developing age-related macular degeneration, an irreversible condition that can lead to blindness, than those in the bottom fifth of consumption.

Age-related macular degeneration affects 1.2 million Americans.

▶ Layer Numbers Continue to Lag Behind 2006

Producers are holding back in their expansions despite record high egg prices, USDA's September Chicken and Eggs report shows. On Sept. 1, table egg type layer numbers were 2 percent below year-earlier levels.

Looking at the top 10 egg-produc-

ing states in table egg layers in flocks 30,000 and above during August compared to year-earlier levels, only Iowa and California posted growth. Iowa was up 4 percent; Ohio was down 7 percent; Indiana, down 2 percent; Pennsylvania, down 5 percent; California, up 2 percent; Texas, down 2 percent; Nebraska, down 7 percent; Minnesota, down 2 percent; Florida, no change; and Georgia, down 1 percent.

▶ Britain Could Face Egg Shortage

Britain's leading egg supplier, Noble Foods, says that the country could face an egg shortage in the run up to Christmas because production is becoming unprofitable. The reason why: the cost of wheat that is used for feed has doubled in price. As a result, according to an article in the *Telegraph*, many farmers are quitting livestock production, unable to afford to feed their animals.

If there is a shortage during the

Christmas season, it would be the first time since World War II. According to Noble Foods, the increase in egg prices has not been enough to make egg production profitable, and prices need to increase another 25 percent.

▶ Canadians Battle Cage-Free Issue

The Union of British Columbia Municipalities was set to debate a resolution in late September, that if passed, could result in a call for British Columbia residents to eat only cage-free eggs. And if that motion is approved, an article in *The Chilliwack Progress* says, "The UBCM could then potentially lobby the provincial government on behalf of municipalities to introduce official legislation to that effect."

One official said that if the province adopts a cage-free policy, the result could be that province residents would likely cross the border to buy cheaper eggs in the United States. **EI**

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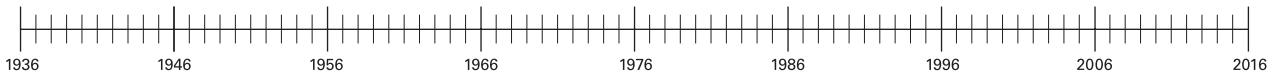
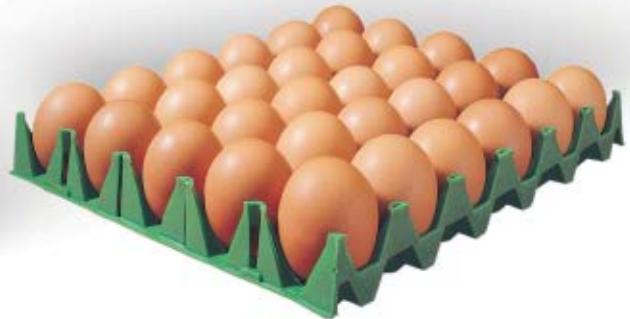
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Get Ready for Intensified Surveillance on SE

By Dr. Simon M. Shane

Although data derived from the FoodNet database indicated a relatively low incidence rate (see glossary) of 2.32 cases of Salmonella Enteritidis (SE) per 100,000 population in the United States during 2005, the plateau of approximately 30 outbreaks per year since 2002 is of concern to regulatory authorities.

The U.S. Centers for Disease Control and Prevention (CDC) has derived a mid-range estimate of 66 percent of incident (new) cases of SE as being attributable to consumption of contaminated eggs. Although subject to debate, the CDC has calculated that approximately 120,000 incident cases of SE are derived from eggs each year in the United States. This is attributed to persistence of infection in flocks in the Midwest and Western states and to a lower level of transmission to consumers in the Mid-Atlantic and Great Lakes regions.

A study conducted by the National Animal Health Monitoring System in 1999, prior to introduction of extensive vaccination, showed that 7 percent of layer houses were infected with SE. Deep-pit units, which represent the majority of in-line complexes erected during the past 20

years, showed a 13 percent prevalence of environmental contamination.

Based on the persistence of SE in the United States and a proven association with shell eggs, the U.S. Food and Drug Administration (FDA), which has jurisdiction over distribution of all food products in terms of the Federal Food, Drug and Cosmetics Act and the Public Health Service Act, has issued a proposed rule relating to "SE prevention measures". The proposed regulations are based on 21 CFR parts 16 and 118. Section 118.5 (a) of 21 CFR will require more frequent assay of the environment of flocks at critical intervals during the production cycle to identify potential infections. Positive assays would then lead to confirmatory tests on eggs from suspect flocks.

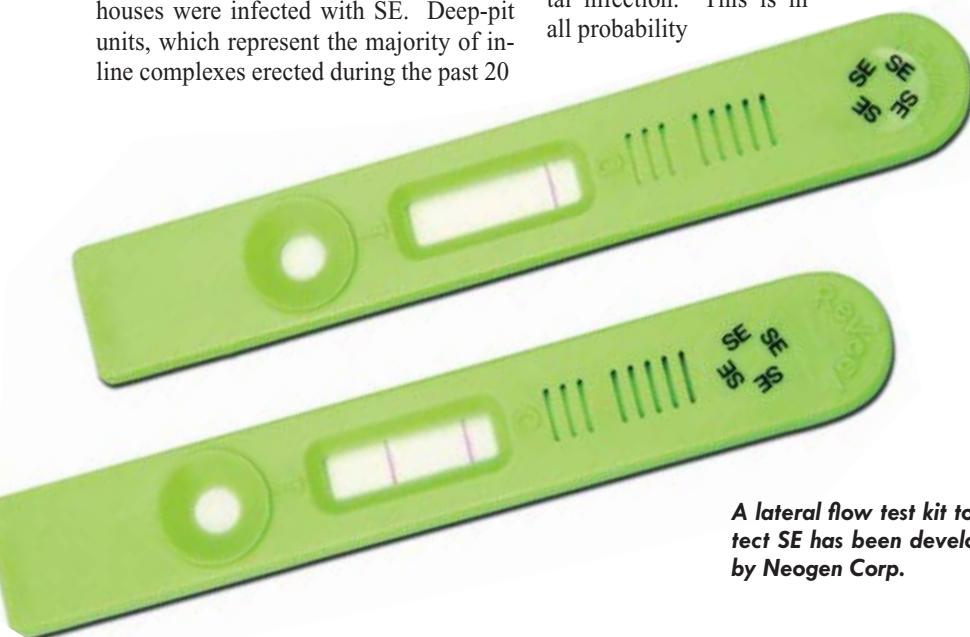
Environmental Sampling

The current industry standard to detect environmental contamination requires drag swabs of accumulated droppings under cages or from egg belts. It is generally accepted that drag swabs are insensitive in their ability to detect environmental infection. This is in all probability

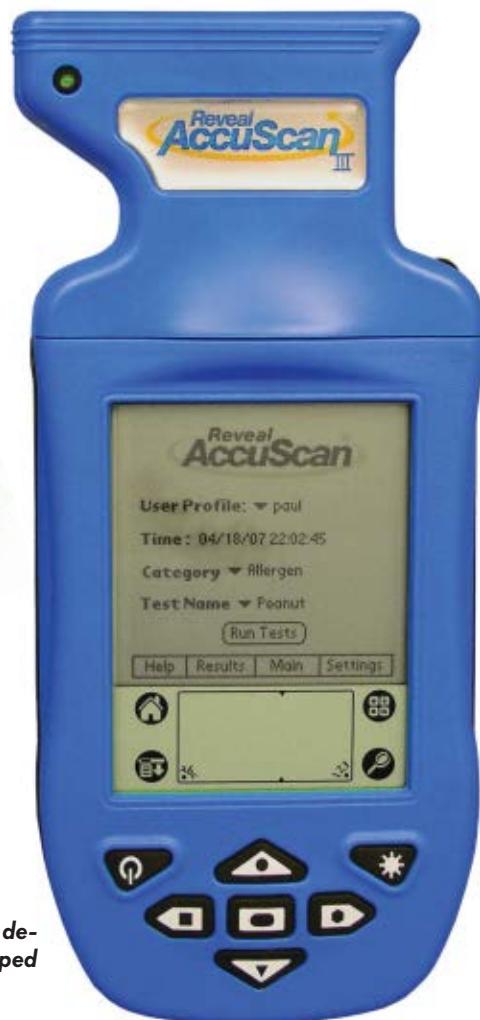
due to the fact that surface contamination with SE may be non-detectable due to the low water activity of the crust covering acceptably dry "coned" manure.

In a recent peer reviewed article, data was published on the examination of 128 environmental drag swabs from two known SE positive flocks located in a Western and a Midwestern state, respectively.

Applying conventional culture procedures, only 23 percent of the swabs derived from manure or egg belts yielded SE.



A lateral flow test kit to detect SE has been developed by Neogen Corp.



A previous field diagnostic study conducted on a Midwest in-line complex demonstrating SE infection yielded five positive assays from 24 drag swabs from the four adjacent houses that were sampled. Given the relatively low sensitivity of drag swab assays to detect SE, it is evident that the UEP program based on sampling flocks only once at about two weeks before depletion has a high probability of generating a false positive result (not detecting environmental contamination).

Since the assay is conducted at the end of the production cycle, failure to detect exposure, which indicates intestinal colonization, may lead to possible vertical transmission during the peri-peak and peri-molt periods. This in turn creates the probability of food borne infection for consumers of undercooked eggs.

Increased frequency of environmental surveillance and more sensitive microbiological assay procedures will be mandated in the near future to identify flocks with intestinal SE colonization. This situation may result in transfer of the pathogen to eggs by trans-ovarial and trans-oviductal transmission if flocks are immunosuppressed or stressed.

Assay for SE

The approved FDA culture method requires a pre-enrichment phase in buffered peptone water followed by enrichment in either Tetrathionate broth or Rappaport-Vassiliadis medium. This is followed by plating on a selective medium such as Brilliant green agar, XLT-4 or Bismuth sulfite agar. Generally, XLT-4 is the preferred medium since it promotes the growth of SE colonies which are identified by their characteristic pink color with black centers.

Presumptive SE colonies are transferred to identifying media (Triple sugar iron agar and Lysine iron agar). Following 24 hours of incubation, the specific changes induced in the medium are indicative of SE. Provisional immunologic identification is carried out using the plate agglutination test procedure using serogroup-D antiserum.

The complete sequence of enrichment, isolation, and identification may take as long as seven to 10 days. Selecting presumptive positive SE colonies from isolation medium requires experience and is subject to inherent operator bias. This factor together with other sources of confounding associated with standard microbiologi-

cal procedures may give rise to either false positive or false negative results.

Polymer Chain Reaction Assay

Recently, polymerase chain reaction technology (PCR) has been adapted to identify SE. The most current innovation is a real-time PCR system developed by microbiologists at the FDA. A fluorescent dye-labeled, gene-specific probe detects segments of the gene *sefA* which is specific to Salmonella group-D strains including SE. An advantage of the system is extreme sensitivity and the assay can detect one organism (live or dead) in the contents of 100 eggs.

The test incorporates high specificity in identifying SE and differentiating the organism from over 50 non-group-D Sal-

cially in company-operated and contract laboratories.

Immuno-Based Test Kits

A lateral flow test kit to detect SE has been developed by Neogen Corp., located in Lansing, Mich. (www.neogen.com). The test, marketed as the Reveal for SE, offers the obvious advantages of low cost, speed, sensitivity, specificity, and reproducibility. The test is highly correlated with results obtained using conventional microbiology incorporating double enrichment and highly selective isolation media. Sample enrichment is still required, especially when assaying eggs which may contain a small number of viable organisms. The test is performed by transferring a minute quantity

Testing Glossary

Incidence: The number of new cases in a population during a specified time period.

Positive predictive value: The number of truly positive cases in a population adjudged positive by a specific test procedure.

Prevalence: The number of cases at a given time in a population at risk of exposure.

Reliability: The measure of consistent reproducibility of a test result under identical conditions.

Sensitivity: The ability of a test to detect a disease or pathogen. High sensitivity is required for screening tests applied in surveillance programs. Highly sensitive tests may generate false positive results

Specificity: The ability of a test to differentiate between the disease or pathogen of significance and other agents. These tests are often applied as a procedure to confirm the positive result revealed by a sensitive test. Highly specific tests may generate false negative results.

monella and non-Salmonella contaminants encountered in egg liquid including *Shigella* spp., *Staphylococcus* spp., and *E. coli*.

The procedure identified seven serotypes of SE including phage type 4 in addition to the more common pt13 and pt8. The real-time PCR technique is capable of providing a result within two days including enrichment prior to assay. The fact that the PCR procedure which has advantages over previous technology was developed by FDA suggests that this method may become a standard and approved procedure to confirm SE transmission.

The PCR technique is suitable for research, reference and regulatory establishments, but the cost, complexity and requirement for trained technicians will limit field diagnostic application, espe-

cially in company-operated and contract laboratories. of the enriched solution into the well of the indicator device. After application the solution diffuses along the solid medium. If SE antigen comprising live or dead organisms is present, binding will occur to specific antibody directed to the fimbrial protein, specific to group-D Salmonella spp. The antibody antigen complex which is conjugated to colloidal gold particles continues to move along the test strip and is detected in a second zone, resulting in the appearance of a visible line.

The kit incorporates a control to confirm correct function of the detector system which is indicated by a second line. If SE is present in the enrichment culture, two lines are visible, one representing the antigen-antibody complex and the second the control. A negative sample will have only the control line indicating correct

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function of the unit.

In extensive trials comparing the Reveal with conventional microbiological culture, the test kit demonstrated sensitivity of 83 percent, specificity of 94 percent, a positive predictive value of 76 percent, and an accuracy of 92 percent. False positives for SE can occur using the test system which cannot differentiate among other group-D Salmonella including *S. Berta*, *S. Pullorum*, and *S. Gallinarum*. With the exception of *S. Berta*, other group-D Salmonella are all epidemiologically significant.

Fortunately in the United States, neither *S. Pullorum* nor *S. Gallinarum* are encountered in commercial operations, and a positive result using the test kit is a substantial indication of the presence of SE. In any event, presumptive SE results should be verified by microbiology or PCR, and samples should be submitted to a designated reference laboratory such as the NVSL for confirmation. The Reveal test does, however, provide a rapid and reliable result to enable appropriate corrective action to be taken. It is reiterated that although sensi-

tive and specific, the Reveal test can only detect SE which is present on the source swab derived from egg belts, fan blades or manure.

The entire detection system is subject to the limitations of sampling. A number of replicate samples, albeit pooled, may therefore be required to identify infected flocks. Naturally increasing the frequency and intensity of sampling will improve the sensitivity of detection. The cost of the Reveal kits including enrichment media is approximately \$150 for 20 assays. This can be compared to a cost of \$20-\$30/microbiological assay as charged by certified commercial laboratories. Laboratory requirements for the Reveal for SE tests, including an incubator for enrichment, are minimal in comparison to a PCR installation which can cost in excess of \$7,000 in addition to the purchase of reagents.

Neogen supplies the AccuScan reader which combines a digital camera and software. The reader provides an objective evaluation of the bands on the test kit, identifies flocks and stores data for download to a comprehensive database.

Take Home Message

Assay of flocks for the presence of SE in the environment or pools of liquid eggs will increase in intensity following adoption of the proposed FDA rule on SE. The Neogen Reveal for SE kit offers the opportunity to establish an inexpensive, practical in-company capability to identify SE-contaminated flocks and complexes. This will form the basis of appropriate action to eradicate infection or to serve as an internal surveillance program to detect SE in operations with no history of infection. **EI**

For more information on Reveal test kits go to www.neogen.com/FoodSafety/R_Index.html.



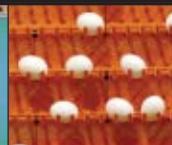
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Expect Cage-Free Innovations

Is there room for any further production system innovations? Absolutely, particularly when it comes to cage-free production, says Mark Oldenkamp, vice president, northwest operations for Valley Fresh Foods, Woodburn, Ore.

Rather than retrofitting existing operations to cage-free, Oldenkamp sees the possibility for new, intensely managed aviary production system complexes in the future.

Unlike what has occurred in Europe, Oldenkamp does not believe “enriched cages” will be used in the United States, noting that enriched cages offer no bird performance advantage, nor are they an improvement for bird liveability. He says, however, that “certain consumers may want to push us that way.”

The challenge, Oldenkamp says, is to educate consumers about the United Egg Producers science-based animal welfare guidelines. Despite current cage-free challenges, such as

attempts to put measures on caged production before the public on ballots in California and Colorado, “I believe cages will be used.”

Oldenkamp also sees the likelihood that producers will have to make envi-

ronmental changes in the years ahead in their production systems, such as possibly using filtration systems to reduce dust to meet air quality guidelines, and changing feeding practices to reduce nitrogen. **EI**

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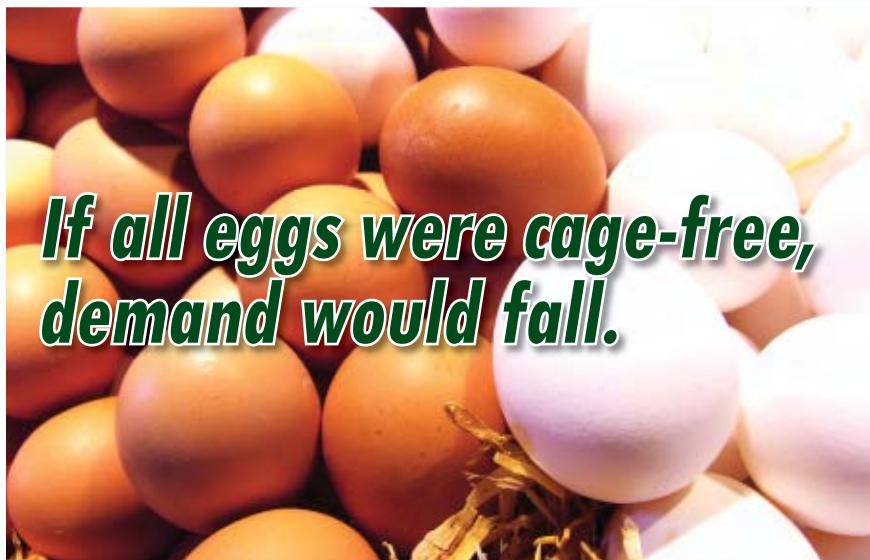
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Value-Added Commands Larger Presence—and Premiums—in Market

Within 3 Years, Specialty Eggs Could Be as Much as 20 Percent of Market



By Edward Clark, Editor

Value-added or specialty eggs will continue to increase, industry experts say, as consumers increase their desire for eggs that are nutritionally enhanced or produced in certain ways.

“Today, slightly over 10 percent of eggs are specialty eggs—brown, nutritionally enhanced, cage-free, and organic,” says Mark Oldenkamp, vice president, northwest operations for Valley Fresh Foods, Woodburn, Ore. Growth has been strong, he adds, “and I don’t think that’s done.” Within three years, Oldenkamp says, specialty eggs could be 15 percent to 20 percent of the total egg market.

Noting that in Japan there are more than 300 types of specialty eggs, compared to about 100 in the United States, Oldenkamp says there is potential for greater growth in this segment of the market.

Organic Eggs

Craig Willardson, president and CEO of Moark, LLC, Chesterfield, Mo., says that value-added eggs “have found a permanent place on the store shelf, just as certain branded eggs have done. Organic is here to stay, it’s just a question of where the demand

level will peak and if there will be sufficient organic grains to supply that demand.” Willardson adds, “The organic question will also be impacted by finding its elasticity on the shelf—at \$5/dozen in many urban markets, with a forecast for scarce grain supply, consumer demand may be tested. New value-added products for eggs will likely show up in other food products, such as Omega-3 did.”

“Value-added will continue to grow,” says Paul Sauder, president of R.W. Sauder Inc., Lititz, Pa. One reason why, he says, “is the whole issue of health and wellness, thus some consumers want more ‘nutritionally enhanced products,’ such as those with added Omega-3 and lutein, fed all vegetarian diets.”

Sauder says that the market share of specialty eggs varies by region of the country. Today, he says, the New York City metropolitan market is probably 30 percent specialty eggs, while in rural parts of Pennsylvania, the percentage of specialty eggs sold is closer to 7 percent to 8 percent. Within five years, Sauder believes specialty eggs could command up to half of the egg market on both coasts, and 10 percent to 15 percent in the middle of the country.

Income, Cage-Free

Sauder says that two factors will contribute to how rapidly the specialty egg market grows. The first is how much disposable income consumers have available in upcoming years, since specialty eggs cost more. The second is how much influence special interest groups have on cage-free production.

Gene Gregory, president and CEO of United Egg Producers, Atlanta, estimates that cage-free and organic egg production has increased from 2 percent of the total to 5 percent today. He adds that the specialty egg sector will continue to grow, and that a segment of the population wants them for health and other reasons, regardless of price. An additional reason for the growth of specialty eggs, he adds, is their increased profitability for stores, and increased premiums for producers.

Gregory says that he does not believe it will happen, but if all production were to become cage-free egg production, demand for eggs would be reduced because some consumers can’t afford to pay two to three times more for their eggs. “People tend to have a reference point for egg prices. If prices get too far out of line, they cut back,” he adds.

Marcus Rust, an owner of Rose Acre Farms, Seymour, Ind., says that one reason why specialty eggs are growing so rapidly this year is that conventional eggs are so high-priced, and some stores have a fixed price for specialty eggs. Thus, the spread in price between conventional and specialty eggs has narrowed. In some cases, he says, specialty eggs are as cheap or even cheaper than conventional eggs.

Larry Seger, President of Wabash Valley Produce, Dubois, Ind., says that niche markets, such as Eggland’s Best and organic, are fine and good to develop, but specialty eggs can become a “slippery slope” that can detract from the regular egg business. “We don’t want consumers cutting back,” he says, noting that cage-free egg prices, for instance, are considerably higher. **EI**

Further Processing Egg Sector Continues to Grow

Will Sector Ever Reach 50 Percent of Total?

By Edward Clark, Editor

The egg processing or further processing sector continues to grow, and that growth is likely to continue in the years ahead, industry experts say.

Today, the egg products business is about one-third of the total, and could be as much as 40 percent within five to 10 years, says Larry Seger, president of Wabash Valley Produce, Dubois, Ind. Products that use processed egg products are under development, in addition to increased breakfast offerings from fast food chains that contain egg products. "The egg products business has been very good," he says.

Gene Gregory, president and CEO of United Egg Producers, Atlanta, notes, however, that egg products' production is actually down 2 percent this year from 2006 levels. With the high prices for shell eggs, egg products' manufacturers are buying fewer eggs to dry. As a result, Gregory points out, dried egg inventories are down 58 percent from year earlier levels. That doesn't mean, however, that demand for egg products has been reduced, he says, just that more inventories are being used to meet demand now

that egg prices have risen.

Is it possible that the processed egg sector could take up half of all eggs produced? "Some time back, we thought it could get up to 50 percent, but I no longer believe so," Gregory says, although he anticipates modest gains each year. The United States adds 3 million people a year, he says, so for the egg products business to be half of total sales, giant strides in egg product per capita use would be necessary.

Gregory continues that it's great - and good for business - that Wendy's is expanding breakfast offerings, and it's nice to be included, but some of those buying a Wendy's breakfast aren't necessarily buying new egg products. They might be switching from purchases of an Egg McMuffin from McDonald's.

Exports Uncertain

One reason why Gregory is cautious in predicting growth of egg products is that the export market is crucial to egg product growth, and countries can very easily slap bans on products for a whole host of reasons.

In the short term, one factor that could curtail the growth on the egg products side

is that more and more customers will be asking for eggs produced meeting animal welfare guidelines like consumer requests on the shell egg side, thus reducing bird numbers, says Mark Oldenkamp, vice president, northwest operations for Valley Fresh Foods, Woodburn, Ore., and increasing liquid egg production costs. But partially offsetting that is an improvement in egg production efficiencies. "You don't gain it all back, but there is not the type of change on cost of production that we thought it would be," he says. On the shell egg side, it was forecast that production costs would increase 10 to 12 cents per dozen, but he says, "it did not happen."

Consumer-Friendly Products

Oldenkamp sees opportunities for liquid egg producers to displace some shell eggs at the retail level with consumer-friendly products packaged for easy use.

Marcus Rust, an owner of Rose Acre Farms, Seymour, Ind., sees the further processing industry eventually becoming 50 percent of the market, but for that to happen, it will take more breakfast item offerings at restaurants—which is happening today, and more convenience foods that contain eggs. **EI**



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Eggshell Spotting/Mottling: What Is It and Why Does It Occur?

By Richard D. Miles and Gary D. Butcher

In spite of all of the basic research that has been conducted in the area of mineral metabolism and eggshell formation, problems which are associated with the eggshell still exist. Even the slightest structural flaw has the potential to compromise the primary biological function of the eggshell, which is to provide a chamber for embryonic development. The eggshell must be structurally sound enough to provide physical protection to the developing embryo throughout incubation while at the same time allow for adequate movement of respiratory gasses and water vapor. Since the developed chick has to emerge from within the egg, the eggshell must also be able to be penetrated during the hatching process.

Commercial table eggs and hatching eggs are continually monitored for quality. Assessing eggs for quality routinely requires that they be evaluated externally and internally. The external evaluation begins with an examination of the overall appearance of the egg and considers factors such as size, shape, color, texture, cleanliness and structural integrity. Internal evaluation requires the use of a light source over which the egg is passed so that certain quality character-

istics can be assessed. It is during this “candling” process that flaws in the eggshell can be detected more easily.

One flaw in the eggshell, which can easily be detected during candling, is shell spotting or “mottling”, as it is sometimes called. When candled, it can be observed that the shells of these eggs have many translucent spots that impart a “marble like” appearance to their shell surface. These spotted/marbled eggs can easily be distinguished from eggs with normal shells. In order to understand the underlying cause of the shell spotting/mottling problem, an appreciation of the basic architectural structure of the eggshell is essential.

Eggshell Architecture

A cross section of an eggshell will reveal that it consists of several morphologically distinct layers. Simply speaking, from the innermost layer towards the outermost layer these are the 1) shell membranes, 2) mammillary layer, 3) palisade layer and finally 4) the cuticle. The inner membrane is very compact and its inner surface has a smooth appearance. On top of the inner shell membrane sits the outer membrane which consists of a network of coarse protein fibers which allows for the initial anchoring of the inner portion of the shell mineral during the first crucial steps of shell formation once the egg reaches the portion of the hen’s reproductive tract known as the uterus (shell gland). The anchoring of the mammillary layer base into the outer shell membrane at specific sites is essential for a proper mineral to membrane cohesion which is the backbone of proper eggshell formation and strength. Once the mammillary layer is securely

It is during the “candling” process that flaws in the eggshell can be detected more easily.

anchored in the outer membrane and eggshell formation continues, the synthesis of the mammillary layer extends outward as “cones” until it makes up approximately 30 percent of the total shell thickness. As shell calcification continues, the palisade layer is formed and uses the mammillary layer as its foundation. The palisade layer makes up approximately 70 percent of the shell thickness and is composed of tall, erect, self-supporting columns of calcium carbonate crystals, commonly called “calcite”.

Eggshell strength and its gas/moisture transport properties are highly influenced by the basic structural organization of the mammillary and palisade layers. Normally, the columns of calcite in these layers are erect, organized and closely associated with one another which results in good shell strength. However, if the columns are not as erect, disorganized and there are a large number of random disorgan-

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ized air spaces among the calcite columns, the strength of the eggshell is compromised. The presence of air spaces among the normally formed calcite columns in the shell is essential because they allow for gaseous exchange between the developing embryo and the outside environment. However, as the components of the eggshell become disorganized, the functional properties of the shell are compromised and the disorganization associated with the air spaces will lead to more rapid moisture loss through the shell.

Coating the outer portion of the eggshell is a cuticle which is sometimes referred to as the "bloom". The cuticle, a slightly water soluble mucopolysaccharide consisting of carbohydrate, protein and fat, is important in shell strength and seals the pore openings on the surface of the shell. The coating of cuticle also serves to minimize shell bacterial penetration and contains a high concentration of the pigments found in brown eggshells.

A normal eggshell contains approximately 94 percent calcite, 4 percent protein and the remaining 2 percent consisting of a mixture of other minerals of which phosphorus and magnesium dominate at a concentration of approximately 0.4 percent each. Research has shown that the eggshell consists of more than columns of calcite crystals. There is a protein matrix which plays a very important role in helping establish and maintain the normal structure and quality characteristics of the eggshell. Factors such as stress and disease in laying hens not only affect the synthesis of these matrix proteins, but also have a negative effect on the positioning of these proteins in the shell. Disorganization of these shell matrix proteins ultimately affects the columnar structure of the calcite crystals and the size and quantity of the air spaces among the crystalline components of the eggshell. Thus, the normal formation of the protein matrix in the shell, as well as the normally formed shell membranes acting as supports for the mammillary layer, are essential for the proper formation and functional properties of the eggshell.

Altered Eggshell Architecture as Cause of Spotting/Mottling

The amount of marble-like spotting of the eggshell, which is seen during candling, is directly proportional to the amount of structural disorganization within the eggshell. The majority of the disorganization associated with the eggshell occurs in the mammillary and palisade layers. When the amount of structural disorganization in these areas is high there is an increase in moisture loss through the shell due to the large number and

size of disorganized air spaces. Thus, an uneven pattern of dehydration occurs once the egg is laid.

As a layer flock ages the quality of their eggshells decline and the percentage of cracks increases. Also, the relative number of eggs with heavily spotted shells increases with age of a layer flock. Research has shown that as the hen ages the egg gets bigger and the shell becomes thinner. Simply, the size of the egg increases and the amount of shell deposition remains somewhat constant and, therefore, the shell thins. The calcite columns in the palisade layer of the shell become shorter with hen age and research in eggshell quality has shown that fracture strength of the eggshell is directly related to the thickness of the palisade layer. In older flocks, the combination of increased spotting and thinner shells has a cumulative negative effect on egg breakage as well as moisture loss. The increased moisture loss has a negative effect on hatchability.

Egg hatchability can be decreased by 3 percent to 14 percent when spotting of the eggshell is high, especially in older breeder flocks. The decline in eggshell quality in older flocks is also highly correlated with an increased bacterial penetration of the eggshell. Minimizing the number of stressors and their intensity in the environment of commercial egg-type hens and breeders will keep the stress level low in the birds and this is usually associated with a decrease in the amount of eggshell spotting/mottling, especially in older flocks. Maintaining proper temperature and humidity in the

egg storage area will also help to minimize moisture loss from the egg, but even with proper egg storage conditions certain eggs will still exhibit the characteristic translucent marble-like spotting/mottling. The weight of a chick that emerges from a heavily spotted egg is usually less than that of a chick from a non-spotted/marbled egg of the same egg weight. This is probably related to the higher amount of dehydration which occurs in these eggs during incubation.

Summary

The water and gas exchange capacity of an egg is a direct function of the conductivity and porosity of its shell. In heavily spotted/mottled eggs the protein fiber matrix of the shell membrane layers, especially in the mammillary layer, is fragile, disorganized and loose resulting in a less dense shell. This leads to the disorganization of the crystalline structure of the mammillary and palisade layers and is the major reason the water and gas exchange capacity of the shell is negatively affected, microbial penetration increases, cracks develop more easily and eggshell spotting/mottling occurs. **EI**

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December

9-11: National Grain and Feed Association (NGFA) 2007 Country Elevator Feed Industry Conference and Trade Show

Chicago, Illinois. Contact: National Grain and Feed Association (NGFA), 1250 Eye St., N.W., Suite 1003, Washington, D.C. 20005. Tel: 202-289-0873. Fax: 202-289-5388. E-mail: info@ngfa.org. Website: www.ngfa.org.

2008

January

23-25: International Poultry Exposition 2008

Georgia World Congress Center, Atlanta, Georgia. Contact: US Poultry & Egg Association, 1530 Cooledge Road, Tucker, Georgia 30084-7804.

Tel: 770-493-9401. Fax: 770-493-9257. E-mail: expogeneralinfo@poultryegg.org. Website: www.poultryegg.org.

March

18-20: Midwest Poultry Federation Convention 2008

St. Paul, Minnesota. Contact: Midwest Poultry Federation, 108 Marty Drive, Buffalo, Minnesota 55313. Tel: 763-682-2171. Fax: 763-682-5546. E-mail: lara@midwestpoultry.com. Website: www.midwestpoultry.com.

June

29 - July 4: XXIII World's Poultry Congress. Convention and Exhibition Centre, Brisbane, Aus-

tralia. Event includes 6th Asian-Pacific Poultry Health Conference, 4th International Ratite Science Symposium & 2008 Australian Poultry Information Exchange. Contact: WPC 2008 Congress. Tel: +61 7 3858 5594; Fax: +61 7 3858 5510. Email: wpc2008@im.com.au. Website: www.wpc2008.com.

2009

January

28-30: International Poultry Exposition 2009

Georgia World Congress Center, Atlanta, Georgia. Contact: US Poultry & Egg Association, 1530 Cooledge Road, Tucker, Georgia 30084-7804. Tel: 770-493-9401. Fax: 770-493-9257. E-mail: expogeneralinfo@poultryegg.org. Website: www.poultryegg.org.

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