

## EGGSHELL APEX ABNORMALITY: THE SILENT THREAT TO EGG QUALITY IN LAYER CHICKENS

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### Abstract

Eggshell apex abnormality (EAA) is an important but often overlooked eggshell defect that can silently affect egg quality, breakage, marketability, and profitability in commercial layer production. Unlike obvious cracked, thin, or misshapen eggs, EAA may remain unnoticed during routine inspection until the affected egg is examined under strong light. The abnormality typically appears at the pointed end of the egg as localised roughness, increased translucency, thinning, and structural weakness, making affected eggs more susceptible to breakage and downgrading. EAA is not simply a calcium-deficiency problem; it reflects the interaction of several factors, including nutrition, heat stress, flock age, reproductive physiology, and infectious diseases. Among infectious factors, *Mycoplasma synoviae* (MS) is consistently associated with EAA, while prior exposure to infectious bronchitis virus may further increase its occurrence. Structural investigations have demonstrated marked alterations in the shell architecture of affected eggs, explaining their reduced mechanical strength. The condition is particularly relevant to intensive layer production systems, where prolonged laying cycles, high environmental temperatures, and infectious challenges can collectively compromise shell quality. Early recognition through visual examination and candling, combined with flock-level assessment and appropriate laboratory testing when MS is suspected, can help identify the underlying cause. Effective management requires a cause-directed approach that combines balanced calcium-phosphorus nutrition with adequate vitamin D<sub>3</sub>, heat-stress reduction, strengthened biosecurity, appropriate vaccination, responsible antimicrobial use, and continuous flock surveillance. Greater awareness of EAA among poultry producers and veterinarians can help reduce abnormal and downgraded eggs, minimise avoidable economic losses, and protect the profitability of modern layer farming. The central message is simple: when an egg looks normal at first glance, it may still be telling you that something is wrong inside the flock.

**Keywords:** Biosecurity, Eggshell quality, Heat stress, Layer chickens, *Mycoplasma synoviae*

### Introduction

Pick up an egg from a layer flock, and at first glance it may look perfectly normal. Hold it against bright light, and a different picture can emerge: a rough patch at the pointed end, a faint boundary, or an area where the shell appears unusually translucent, thin, and weak. This subtle change, known as eggshell apex abnormality (EAA), is a shell defect that can quietly reduce egg quality and add to economic losses in commercial layer production. An egg appears simple, but its

Shell formation involves complex biological processes, including the hen's nutrition, reproductive system, metabolism, and health. Eggshell quality affects breakage (cracks or misshapes), grading, marketability, and profit, often going unnoticed until it affects quality and flock performance. These changes are visible under strong light, revealing a demarcation zone about 2 cm from the apex and indicating that EAA affects internal shell architecture and strength; EAA is more than a

calcium (Ca) deficiency, as shell formation depends on Ca, phosphorus, vitamin D<sub>3</sub>, and reproductive physiology. Environmental stresses like heat can worsen shell quality by disrupting nutrient metabolism and immunity. Flock age also affects shell strength due to physiological changes. Infections such as *Mycoplasma synoviae* (MS) are linked to EAA, especially in the mamillary knob region. Previous exposure to infectious bronchitis virus may raise EAA risk, along with other multiple factors including nutritional, environmental, age-related, and health factors, rather than a single cause. The condition has been reported internationally, where MS infection correlates with ultrastructural changes in the shell. Similar apex abnormalities indicating MS have been seen in commercial Babcock layers in Tamil Nadu, India. A large 2015-2017 French study found EAA in about 7.7% of flocks, showing it's a widespread issue that impacts mainly economically, with affected birds often showing no clinical signs but suffering reduced egg production, breakage, and downgraded eggs. It peaks between 25-40 weeks, causing a 2-7.7% drop in egg production and 0.66-1.35% of eggs with abnormalities. In dense, multi-age systems, infectious agents like MS can spread quickly, turning minor defects into ongoing economic problems. Diagnosis requires more than visual shell checks; candling and shell analysis can help, but recurring cases need investigation of flock health, nutrition, environment, and diseases. Polymerase chain reaction or bacterial culture of swabs and samples can identify MS, and advanced microscopy reveals microscopic damage. Managing EAA requires a cause-based, flock-wide approach involving balanced nutrition, vitamin D, heat stress control, biosecurity, vaccination, responsible antibiotic use, and surveillance. Early detection, cause identification, and prevention can reduce egg losses and protect productivity. For Indian poultry producers, the issue deserves particular attention. Eggshell apex abnormality should therefore be viewed not as an isolated shell defect, but as a possible

warning sign of broader flock-level problems. Recognising the condition early is the first step. The question, therefore, is not simply "How can we make the shell harder?" but rather "Why is the shell failing at the apex in the first place?" Understanding that distinction is essential for effective prevention, timely intervention, and protection of farm profitability (Bain, 2005).

### The Biology of Eggshell Formation

Eggshell formation is a precisely coordinated physiological process that occurs predominantly in the shell gland, or uterus, where minerals form a protective shell for the embryo. During this phase, minerals are deposited systematically to create a hard, protective shell that safeguards the developing embryo and preserves egg quality after laying. Calcium is the primary mineral required for eggshell formation, sourced from diet or skeletal reserves. Maintaining proper dietary Ca, supported by vitamin D<sub>3</sub> for absorption and metabolism, enables effective utilisation of dietary Ca for shell development and shell quality. Phosphorus and other nutrients also play crucial roles in creating a structurally sound eggshell. Simply increasing Ca intake may not fix all shell issues, emphasising the need for a balanced diet of Ca, phosphorus, vitamin D<sub>3</sub>, and other nutrients for proper shell formation. The quality of the final eggshell depends not only on mineral content but also on the organisation of the shell's internal structure. The shell has specialised structural regions that contribute to its mechanical strength. Among these are the mamillary knobs (key sites for shell mineralisation) and the palisade layer (structural framework of the shell). Normal eggshell formation depends on the hen's overall physiological conditions, such as flock age, environmental temperature, nutritional status, and reproductive health, which can influence shell formation. Heat stress is particularly pronounced in hot climates, where high temperatures can reduce feed intake and egg production while also affecting metabolism, immunity, gut health, oxidative balance, and reproductive

performance. Thus, eggshell formation should be regarded as the outcome of an integrated biological system rather than a process controlled by a single dietary mineral. Any disruption in the interaction between nutrition, mineral metabolism, environmental conditions, flock age, and reproductive health can potentially contribute to deterioration in shell quality, including abnormalities occurring specifically at the apex.

### Eggshell Apex Abnormality

Eggshell apex abnormality is a defect affecting the pointed end of an egg, causing a localised shell alteration. Affected eggs may show a rough surface, increased translucency, thinning, and a visible difference between the apex and the rest of the shell, which weakens the shell and raises breakage risk. Eggshell apex abnormality features a clear demarcation zone, about 2 cm from the apex, visible under bright light, making candling useful for detection. The affected area appears more translucent with an uneven, rough surface. Studies show affected eggs have marked changes in shell ultrastructure, including about 47% reduction in the inner palisade layer and 64% loss of mammillary knobs, which are crucial for shell mineralisation. These structural alterations make eggs more vulnerable to damage, and EAA should be seen as a structural defect, not just a cosmetic one. The condition may occur without obvious clinical signs in the hen. The presence of EAA in eggs can early indicate factors interfering with eggshell formation, including *Mycoplasma synoviae*, which changes the mammillary knob, as well as nutrition, heat stress, flock age, and infectious agents, making recognition of the defect relevant to flock health. Understanding the characteristic appearance and structural features of EAA is therefore the first step toward recognising the problem at farm level. Eggshell apex abnormality isn't confined to specific regions or systems; first identified in the Netherlands, it is now reported in commercial layer flocks globally. The rise in reports indicates that EAA is a broader egg-quality issue linked to modern

layer production, not just a regional problem (Catania et al., 2010).

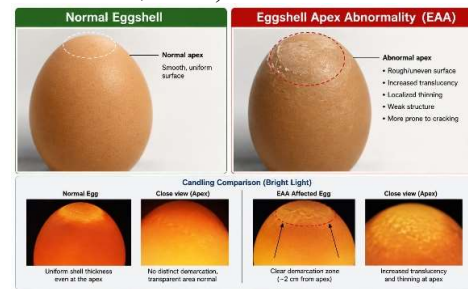


**Fig. 1:** Comparative visual and candling characteristics of normal eggshell and eggshell apex abnormality

### Mechanism of Eggshell Apex Abnormality Formation

EAA develops when the normal process of eggshell formation and mineralisation is disturbed, particularly during the final stages of shell deposition in the shell gland (uterus). *Mycoplasma synoviae* may affect the reproductive tract and interfere with normal shell formation, resulting in localised thinning and structural weakness at the apex. Infectious bronchitis virus can damage the oviduct and disrupt the normal secretion and organisation of eggshell matrix proteins, leading to irregular or poor-quality shell deposition. Nutritional deficiencies or imbalances, particularly inadequate Ca, available phosphorus, or vitamin D<sub>3</sub>, reduce the availability and utilisation of minerals required for proper calcification, resulting in a weak, thin shell. Heat stress further worsens the problem by reducing feed intake and altering Ca and acid-base metabolism; increased panting can contribute to respiratory alkalosis, reducing Ca availability for shell formation. Age-related changes in older laying hens can also decrease the efficiency of Ca deposition as egg size increases, resulting in thinner shells. In addition, environmental and management stressors may disturb Ca utilisation, shell-gland function, and the timing of ovulation and shell formation. When these factors occur individually or, more importantly, in combination, they can disrupt the coordinated process of shell-matrix formation and Ca deposition, making the apex

particularly thin, translucent, and fragile, and ultimately producing the characteristic EAA.

### Major Factors Associated With Eggshell Apex Abnormality

Eggshell apex abnormality is a multifactorial eggshell defect, and its occurrence cannot be attributed to a single nutritional or infectious factor. Normal eggshell development depends on the interaction of nutrition, environmental conditions, flock age, reproductive physiology, and infectious diseases. Among these, nutritional imbalance, heat stress, prolonged laying, and *Mycoplasma synoviae* infection are particularly important considerations when EAA recurs in a layer flock (Cisneros-Tamayo et al., 2020).

#### Nutrition

Nutrition plays a central role in maintaining strong and uniform eggshells. Although Ca is the major mineral deposited during shell formation, simply increasing dietary Ca is not a universal solution for eggshell abnormalities. Efficient shell formation requires an appropriate balance of Ca, phosphorus, and vitamin D<sub>3</sub>, together with other nutrients and trace elements involved in mineral metabolism. During extended laying periods, factors such as Ca level, limestone particle size, and feeding strategy can significantly influence shell quality. During extended laying periods, dietary Ca concentration, limestone particle size, and overall feeding strategy can influence eggshell quality. In late-laying hens, supplementation with vitamin D<sub>3</sub> or 25-hydroxyvitamin D<sub>3</sub> has been reported to improve laying performance, plasma Ca concentrations, and eggshell quality when incorporated into an appropriately balanced nutritional programme. Therefore, when EAA is observed, evaluate the nutritional programme as a whole rather than increasing Ca alone. Adequate Ca availability, appropriate Ca–phosphorus balance, and sufficient vitamin D<sub>3</sub> support normal shell formation.

#### Heat Stress

Heat stress represents another important challenge to eggshell quality, particularly in hot climatic regions. High environmental temperatures can reduce feed intake and egg production and may compromise shell quality while also affecting metabolism, immunity, gut health, oxidative balance, and reproductive performance, creating several pathways through which environmental stress may affect eggshell formation. Heat stress is particularly relevant for intensive layer production in India, where high environmental temperatures may coincide with periods of active egg production. Maintaining effective ventilation, ensuring adequate water availability, and providing appropriate nutritional management are therefore important components of maintaining shell quality under heat-stress conditions. Heat stress should therefore be considered part of the overall EAA risk assessment rather than an independent shell-quality problem. When EAA occurs during hot periods, examine environmental conditions and flock management alongside nutritional and disease-related factors.

#### Flock Age

Flock age also influences eggshell quality through complex physiological changes in prolonged laying cycles; the oviduct, skeleton, and intestine may affect their ability to maintain strong, uniform shell formation. Eggshell apex abnormality is particularly relevant during peak production, with the condition being reported in flocks between approximately 25 and 40 weeks of age. This period matters because birds face high production demands while meeting the physiological requirements for repeated eggshell formation. Consequently, incorporate shell quality monitoring into routine flock management, particularly during periods of high production. Early recognition of increasing EAA incidence can help identify nutritional, environmental, and infectious factors before the problem becomes economically significant.

### Infectious Disease

Among infectious factors, *Mycoplasma synoviae* is an important organism associated with EAA and causes characteristic eggshell apex abnormalities, including changes in the shell's ultrastructural organisation. Evidence suggests other factors can contribute to its occurrence, and prior exposure to infectious bronchitis virus may further increase the risk of EAA. Thus, consider infectious disease within the condition's broader multifactorial context. When EAA occurs repeatedly, particularly alongside reduced egg production or respiratory signs, consider MS as a potential contributing factor. Nevertheless, an abnormal shell alone does not establish MS as the cause, and appropriate diagnostic investigation is required. Therefore, EAA management should focus on identifying the combination of factors operating within the individual flock rather than searching for a single universal cause. The EAA condition presents particular difficulties in high-density, multi-age production environments. When MS is involved, the pathogen can spread swiftly throughout the flock, potentially making EAA a persistent issue rather than an isolated shell defect. The concurrent outcomes include decreased egg production, abnormal shell morphology, increased breakage rates, and diminished market value, collectively imposing sustained economic burdens on producers. Notably, EAA may evade detection during routine assessments when no immediate clinical signs are present, unlike acute disease outbreaks. Instead, losses tend to accrue gradually, with producers noticing reduced egg quantity or higher downgrade rates without necessarily recognising apex abnormalities as indicative of EAA (Feberwee et al., 2009).

### Diagnosis of Eggshell Apex Abnormality

Early recognition of EAA matters because affected eggs may appear normal during routine inspection, while characteristic changes become more evident on careful examination or under strong light. Accurate

diagnosis should combine shell appearance, egg examination, flock-level investigation, and appropriate laboratory testing, particularly when *Mycoplasma synoviae* (MS) is suspected (Jeon et al., 2014).

### Visual examination

Visual examination provides the simplest and most practical first step in identifying EAA. Affected eggs typically show rough or irregular shell surfaces, increased translucency, localised thinning, and greater susceptibility to cracks and breaks, particularly around the apex. The abnormality may be difficult to recognise during routine handling, especially when the external appearance is only mildly altered. Examination under a strong light can improve recognition of the characteristic translucency associated with EAA. Candling can help reveal the affected region and distinguish the abnormal apex from the apparently normal shell surrounding it. However, treat visual identification as a screening method. The characteristic appearance can indicate EAA, but it cannot establish the underlying cause of the shell abnormality.

### Flock-level investigation

When EAA occurs repeatedly within a flock, the investigation should extend beyond individual eggs. Important flock-level factors include flock age, nutritional management, environmental stress, egg production, shell quality, mortality, and infectious disease status. Respiratory signs, a decline in egg production, or other evidence suggestive of MS infection alongside characteristic apex abnormalities may increase suspicion of an infectious component. Nevertheless, interpret these observations together rather than using them independently to diagnose EAA. Flock history is particularly valuable because EAA is multifactorial, and nutritional imbalance, heat stress, prolonged laying, and infectious disease can potentially contribute to deterioration in shell quality. Therefore, identifying when EAA first appeared and whether its incidence changes with flock age, environmental conditions, or production stage can guide further investigation.

**Laboratory confirmation**

When MS is suspected, laboratory testing can provide additional evidence regarding its involvement. Tracheal or oropharyngeal swabs and, where appropriate, samples from the reproductive tract can be examined using polymerase chain reaction (PCR) and/or bacterial culture. These approaches can help determine whether MS is present in the flock. Serological testing can also provide evidence of flock exposure to MS. However, a positive serological result indicates exposure and does not, by itself, prove that MS caused the observed EAA. This distinction matters because EAA may arise from interactions among several infectious and non-infectious factors. Therefore, interpret laboratory findings alongside shell characteristics, flock history, production records, and other evidence of disease. This integrated approach reduces the risk of incorrectly attributing every abnormal shell to MS.

**Advanced Examination**

Where appropriate facilities are available, scanning electron microscopy (SEM) and other advanced imaging techniques can characterise the microscopic abnormalities associated with EAA. Such techniques can provide detailed information regarding alterations in the shell's internal architecture, including changes in the palisade and mammillary knob regions. These structural investigations are particularly useful for understanding the biological basis of EAA and explaining the increased mechanical weakness observed in affected eggs. However, they are generally more specialised than the visual and flock-level approaches available for routine field investigation.

**Practical Solutions and Prevention**

There is no single treatment for EAA across all farm conditions, as it can result from infectious, nutritional, environmental, and management factors. Effective management needs a cause-focused, flock-wide approach, especially if MS infection is suspected or confirmed. The key priority is biosecurity,

since MS spreads through vertical and horizontal transmission. Reduce movement between houses and age groups, maintain flock separation, and control the movement of personnel and equipment. Include regular flock health monitoring in the biosecurity plan. Vaccination is important in controlling EAA when MS is involved. Live M. synoviae vaccines greatly reduce MS-related EAA, but should complement, not replace, biosecurity and proper flock management. Develop vaccination programmes with veterinary advice, considering flock health, existing schedules, and regulations. When MS is suspected or confirmed, appropriate vaccination can help lower EAA occurrence and impact as part of an integrated control plan. Antibiotics may offer temporary relief but are not a permanent solution. Oxytetracycline can temporarily suppress abnormal egg production, but EAA may recur after stopping treatment. Use antimicrobials only under veterinary guidance, following withdrawal and regulatory rules. Addressing infectious causes alone does not ensure sustainable control without also improving nutrition, environment, and management. Optimising flock management is essential for prevention and includes balanced nutrition, adequate Ca, phosphorus, and vitamin D, good feed and water quality, and heat-stress control to support eggshell formation. Simply increasing Ca isn't a universal solution; eggshells depend on coordinated use of Ca, phosphorus, vitamin D<sub>3</sub>, and other nutrients. During high temperatures, ventilation and water availability are crucial because heat stress reduces feed intake, egg production, shell quality, and affects metabolism, immunity, gut health, oxidative balance, and reproduction. Continuous monitoring is vital, as EAA may occur without clinical signs. Regularly check egg production, EAA incidence, shell quality, mortality, and flock health to detect early changes. When MS is suspected, use ELISA with PCR or qPCR for complementary flock exposure and molecular detection info. Always interpret lab results with shell traits, flock history, and

performance, since MS exposure alone doesn't confirm the organism causes EAA. Regular monitoring of production metrics, including egg output, shell integrity, EAA incidence, and mortality, is essential for effective flock management. Ongoing surveillance enables early detection of deviations, allowing investigation of nutritional, environmental, management, or infectious factors before significant economic impact. The economic implications of EAA underscore the importance of preventative strategies over reactionary measures. Implementing balanced nutrition, heat-stress mitigation, enhanced biosecurity protocols, health monitoring, and investigation of infectious agents can reduce EAA incidence and persistence. Consequently, EAA should be considered an economically significant issue related to eggshell quality and flock health management rather than merely an aesthetic shell anomaly. Overall, successful prevention and management of EAA depend on an integrated approach involving accurate diagnosis, strong biosecurity, appropriate vaccination where indicated, balanced nutrition, effective heat-stress management, responsible antimicrobial use, continuous flock surveillance, and veterinary oversight. Because EAA is multifactorial, interventions should target the underlying factors identified within the individual flock rather than relying on a single corrective measure. This comprehensive approach can reduce abnormal and downgraded eggs, minimise breakage-related losses, and protect egg quality and the profitability of commercial layer production (Srinivasan & Murthy, 2020).

## Conclusion

Eggshell apex abnormality is an important but often overlooked challenge in modern layer production because it can compromise eggshell quality, increase breakage and downgrading, and contribute to economic losses without producing obvious clinical signs in affected birds. The condition is multifactorial and involves interactions among several factors, including *Mycoplasma synoviae* infection, nutrition, heat stress, flock age, reproductive physiology, and other infectious or environmental challenges. Therefore, EAA should not be seen as simply a Ca-deficiency problem or automatically attributed to MS infection. Early recognition through careful examination and candling, followed by appropriate flock-level investigation and laboratory testing when indicated, can help identify the factors contributing to the problem. Effective management requires an integrated approach involving strong biosecurity, appropriate vaccination where indicated, balanced Ca-phosphorus nutrition with adequate vitamin D<sub>3</sub>, effective heat-stress management, responsible antimicrobial use, and continuous surveillance of egg production, shell quality, EAA incidence, and flock health. Veterinary oversight is particularly important when an infectious cause is suspected. By recognising EAA early and addressing its underlying causes rather than relying on a single intervention, producers can reduce abnormal and downgraded eggs, minimise avoidable breakage and production losses, and improve the overall quality and profitability of commercial layer production.

## References

- Bain, M.M. (2005). Recent advances in the assessment of eggshell quality and their future application. *World's Poultry Science Journal*, 61, 268–277.
- Catania, S., Bilato, D., Gobbo, F., Granato, A., Terregino, C., Iob, L., & Nicholas, R. A. (2010). Treatment of eggshell abnormalities and reduced egg production caused by *Mycoplasma synoviae* infection. *Avian diseases*, 54(2), 961-964.
- Cisneros-Tamayo, M., Kempf, I., Coton, J., Michel, V., Bougeard, S., de Boissésou, C., Lucas, P., Bâyon-Auboyer, M.H., Chiron, G., Mindus, C. & Gautier-Bouchardon, A.V. (2020). Investigation on eggshell apex abnormality (EAA) syndrome in France:

- isolation of *Mycoplasma synoviae* is frequently associated with *Mycoplasma pullorum*. *BMC Veterinary Research*, **16**, 271.
- Feberwee, A., de Wit, J.J. & Landman, W.J.M. (2009). Induction of eggshell apex abnormalities by *Mycoplasma synoviae*: field and experimental studies. *Avian Pathology*, **38**(1), 77–85.
- Jeon, E.O., Kim, J.N., Lee, H.R., Koo, B.S., Min, K.C., Han, M.S., Lee, S.B., Bae, Y.J., Mo, J.S., Cho, S.H., Lee, C.H. & Mo, I.P. (2014). Eggshell apex abnormalities associated with *Mycoplasma synoviae* infection in layers. *Journal of Veterinary Science*, **15**(4), 579–582.
- Srinivasan, P. & Murthy, T.R.G.K. (2020). *Prevalence of egg shell apex abnormalities in commercial layer chicken of Namakkal region of Tamil Nadu*. *Journal of Animal Research*, **10**(5), 759–764.

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