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Akshaya P
Department of Animal Nutrition, Veterinary College and Research Institute, Namakkal, Veterinary and Animal Sciences University, Tamil Nadu, India

Kumaravel V
Department of Animal Nutrition, Veterinary College and Research Institute, Namakkal, Veterinary and Animal Sciences University, Tamil Nadu, India

Vasanthakumar P
Department of Animal Nutrition, Veterinary College and Research Institute, Namakkal, Veterinary and Animal Sciences University, Tamil Nadu, India

Corresponding Author:
Kumaravel V
Department of Animal Nutrition, Veterinary College and Research Institute, Namakkal, Veterinary and Animal Sciences University, Tamil Nadu, India

Seasonal impacts on layer chicken performance: Challenges and mitigation strategies

Akshaya P, Kumaravel V and Vasanthakumar P

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Abstract
Poultry farming significantly contributes to the Indian agricultural sector, accounting for 8.5% of agricultural GDP and producing over 122 billion eggs annually. The industry faces severe challenges due to seasonal stress, particularly in Indian tropical climates. High ambient temperatures during summer can reduce feed intake by 20-30%, egg production by 25-35% and shell quality by 15-20%, with increased incidence of cracked eggs further exacerbating economic losses. This review highlights the physiological and production impacts of heat and cold stress on layer chickens, focusing on eggshell quality. Nutritional interventions, such as increasing dietary calcium levels by 4.5-5% and supplementing vitamin D_3, improve shell quality and egg production during heat stress. Additionally, environmental strategies such as ventilation systems that lower house temperature by 5-7°C, reduce mortality by 10-15% and enhance productivity. Region-specific, low-cost innovations and smart-housing technologies are vital for strengthening the sustainability and resilience of the Indian poultry sector amidst climatic challenges.

Keywords: Seasonal impact, Layer chickens, performance, mitigations

Introduction
India plays a major role in global poultry egg production. According to FAOSTAT data for 2020, India ranks third in egg production with 129.60 billion eggs during 2021-22 and a CAGR of 7.4%. However, climatic variability poses significant challenges, with temperature extremes reducing production by up to 30%, particularly in tropical and subtropical regions. Effective management of seasonal stress is critical for maintaining consistent productivity and ensuring the economic viability of the poultry sector.

Impact of high ambient temperatures
Effects of heat stress on Layer chickens
Physiological impacts
Heat stress occurs when temperatures exceed the thermoneutral zone of 16-26 °C, causing birds to struggle to dissipate excess body heat. In India, summer temperatures often exceed 40 °C, leading to elevated respiration rates (panting), reduced feed intake and metabolic disorders. Birds experiencing severe heat stress exhibit respiration rates exceeding the normal 30-40 breaths per minute (Etches *et al*., 2008) [2]. Core body temperatures may increase by 1-2 °C, leading to oxidative stress, immunosuppression, and organ damage (Mashaly *et al*., 2004) [6].

Effects on feed intake and egg production
High temperatures directly reduce feed intake by 20-30%, leading to diminished nutrient availability and a 25-35% drop in egg production (Renaudeau *et al*., 2012) [8]. At 30 °C, feed intake decreases from 110 to 90 g/day, and egg mass production drops by 20-25%. Egg weight is reduced by 3-5 g per egg, further lowering market value.

Eggshell quality problems
Heat stress reduces laying performance and egg quality by decreasing feed intake and the direct physiological effects of high temperature. Thinner eggshells and altered shell membrane properties likely contribute to lower shell quality in high temperatures (Lin *et al*., 2004) [5].

Hyperventilation, a response to heat stress, lowers blood bicarbonate levels by 10-15%, disrupting the synthesis of calcium carbonate, the primary shell component. Field data revealed a 20% higher prevalence of cracked eggs during peak summer compared to winter, leading to significant economic losses (Kumaravel *et al*., 2024) [4].

Nutritional strategies to mitigate heat stress

Dietary adjustments

High environmental temperatures disrupt calcium and phosphorus metabolism in poultry, reducing blood calcium levels and negatively impacting egg weight and shell strength. Calcium and vitamin D_3 are essential for eggshell formation, bone health and immune function. However, reduced feed intake during heat stress leads to mineral deficiencies and poorer egg quality (Nascimento *et al*., 2014) [7]. Older hens are more affected due to reduced vitamin D_3 activation, resulting in larger, thinner-shelled eggs. Vitamin D_3 supplementation is critical for maintaining calcium balance, especially in high-producing birds.

Antioxidants and vitamins

Jena *et al*. (2013) [3] found that a combination of vitamins C (200 mg/kg feed) and E (250 mg/kg feed) enhances the antioxidant status of coloured broiler breeder hens under natural hot and humid stress.

Probiotics and Prebiotics

Salem and El-Dayem (2024) [10] reported that adding probiotics, prebiotics, or both (synbiotics) to the diets of laying hens in hot climates did not significantly improve egg production or feed conversion ratios. To maximize the effectiveness of these feed additives, feed should be stored in cool conditions to preserve their viability.

Environmental management

Ventilation and cooling systems

Cooling systems, such as evaporative cooling pads, can lower house temperatures by 5-7 °C, reducing mortality and improving egg production. Increased ventilation rates significantly alleviate heat stress in layer birds (Ruzal *et al*., 2011) [9]. High ventilation rates also reduce thyroid gland activity, as evidenced by lower plasma T_4 levels, enabling adaptation to heat stress (Yahav, 2009) [12].

Housing modifications

Houses equipped with reflective roofing and thermal insulation reduce indoor temperatures by 2-4°C, further mitigating heat stress.

Impact of low ambient temperatures

Effects of cold stress on layer chickens

Cold stress affects chickens in regions where winter temperatures drop below 15°C, leading to increased energy expenditure for thermoregulation. Birds consume 10-15% more feed, but egg production often decreases, reducing feed efficiency (Sayed and Downing, 2011) [11]. Mortality rates increase by 10–15%, particularly in poorly insulated housing (Daghir, 2008) [1].

Strategies to mitigate cold stress

Dietary energy adjustments

High-energy diets with 5-7% fat improve body temperature regulation, increasing egg production by 10-15% during winter months (Sayed and Downing, 2011) [11].

Environmental adjustments

Insulated roofing and localized heating systems help maintain stable temperatures, reducing mortality rates by 10%.

Integrated seasonal stress management

Feeding innovations

Incorporating microencapsulated minerals, essential amino acids and enzymes improves nutrient utilization and enhances egg production by 15-20% under stress conditions. Adjusting the feeding schedule by providing feed during cooler parts of the day in summer and warmer parts during winter optimizes nutrient intake.

Technological interventions

Automated climate control systems equipped with temperature sensors and real-time data collection capabilities significantly improve housing conditions, boosting productivity by 20-30%.

Conclusion

Seasonal stress significantly impacts productivity in Indian poultry farming, with challenges such as reduced feed intake, lower egg production and poor eggshell quality resulting in economic losses. Effective mitigation strategies include nutritional adjustments, such as enhanced calcium supplementation and the use of antioxidants and probiotics, as well as housing modifications and climate-smart technologies. Future research should focus on scalable, low-cost solutions tailored to India’s diverse climatic conditions to ensure sustainable poultry production.

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