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Case Report

CLINICAL INVESTIGATION OF FATTY LIVER HEMORRHAGIC SYNDROME IN A 57-WEEK-OLD COMMERCIAL LAYER FLOCK - A CASE REPORT

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ABSTRACT

A 57-week-old flock of Isa Brown laying hens in Maiduguri, Nigeria, experienced a sudden decline in egg production and increased mortality, prompting veterinary investigation. Despite adherence to industry-standard practices, including vaccination schedules and a balanced commercial feed, the farmer reported a 5.3% mortality rate over two weeks. Clinical examination revealed pale combs and wattles, lethargy, and poor egg quality. Necropsy findings included enlarged, friable, hemorrhagic livers with excessive abdominal fat deposition, suggestive of Fatty Liver Hemorrhagic Syndrome (FLHS). Histopathological analysis confirmed FLHS, demonstrating hepatic lipidosis, sinusoidal congestion, and hemorrhagic necrosis. Differential diagnoses, including infectious and nutritional diseases, were ruled out based on clinical, pathological, and feed composition evaluations. Management interventions focused on dietary reformulation to lower fat and carbohydrate content while incorporating lipotropic agents and multivitamin supplementation to improve hepatic lipid metabolism and systemic health. Environmental modifications, including enhanced ventilation and partial transition to deep litter housing, aimed to mitigate heat stress and encourage physical activity. Over a two-week period, mortality decreased significantly, and egg production improved in both quantity and quality. Comb and wattle pigmentation normalized, reflecting restored systemic health. This case highlights the importance of comprehensive diagnostic and management strategies in addressing metabolic disorders in commercial poultry. The findings emphasize the critical role of dietary and environmental optimization in the prevention and management of FLHS, contributing to improved productivity and welfare in layer flocks.

Keywords: Battery cage, Fatty Liver Hemorrhagic Syndrome, Histopathology, Mortality, Necropsy

INTRODUCTION

Fatty Liver Hemorrhagic Syndrome (FLHS) is a significant metabolic disorder predominantly affecting high-yielding commercial laying hens. Characterized by excessive lipid accumulation in the liver, hepatic hemorrhages, and sudden mortality, the condition adversely impacts flock health, egg production, and economic returns (Shini *et al*., 2019; Guo *et al*., 2021). First identified in the mid-20th century, FLHS continues to challenge poultry production systems worldwide, particularly those employing intensive management practices to meet high productivity demands (Anene *et al*., 2023; Muir *et al*., 2023). Layers fed diets high in fat or calories are particularly susceptible to FLHS, with additional risks arising from genetic, nutritional, and management factors (Bain *et al*., 2016; Brouklogiannis *et al*., 2023).

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The pathophysiology of FLHS stems from an imbalance in lipid metabolism, leading to hepatic degeneration and intraparenchymal hemorrhages. While clinical signs often remain subtle, indicators such as reduced egg production, altered body condition, and increased feed conversion ratio (FCR) may precede acute mortality (Zhuang *et al.*, 2019; Oke *et al*., 2024).

Necropsy typically reveals friable, hemorrhagic livers and significant abdominal fat deposition. Beyond economic losses, FLHS raises critical welfare concerns due to preventable mortalities and compromised flock well-being (Anene *et al*., 2023; Valkova *et al*., 2023).

Several factors have been implicated in the onset of FLHS, including high-energy diets that exacerbate hepatic lipogenesis, deficiencies in lipotropic nutrients (e.g., choline, methionine, and vitamin E), genetic predisposition in high-yielding strains, and environmental stressors such as inadequate ventilation and high stocking density (Choi *et al*., 2012).

Additionally, the natural hormonal dynamics during peak egg production, particularly the physiologically elevated estrogen levels, contribute to hepatic lipid deposition in layers, as reported in both experimental and field studies (Palmisano *et al.*, 2017; Zhang *et al.*, 2022).

This case report examines the clinical presentation, diagnostic findings, and management factors associated with FLHS in a 57-week-old commercial layer flock.

CASE PRESENTATION

Case History and Signalmen

A poultry farmer in Maiduguri, Nigeria, managing a flock of 57-week-old Isa Brown laying hens, sought veterinary intervention following a sudden and concerning decline in egg production accompanied by increased mortality. The flock, initially comprising 510 birds, was obtained from Amo Farms, a reputable supplier of high-quality commercial layers in Oyo State, Nigeria.

The birds were housed in battery cages under an intensive management system, reflecting industry-standard practices aimed at optimizing productivity and biosecurity. The farmer reported that prior to the onset of the problem, the flock consistently produced an average of 374 eggs ± 3 eggs per day, equivalent to approximately 12 crates with an additional 14 eggs (73.3% egg production rate, calculated as [374/510] × 100). *This* consistent production level was maintained for three weeks before a gradual decline in egg production was observed. The decline progressed steadily over a period of two weeks, ultimately reducing egg collection to an alarming level of just 4 to 5 crates per day. In addition to this production drop, the farmer recorded a cumulative mortality of 27 birds (5.3%) during the same period.

The feeding regimen consisted of "Laymore," a high-energy commercial layer feed formulated to meet the nutritional demands of high-performing birds. Additionally, the flock's vaccination schedule was meticulously followed, ensuring up-to-date protection against major avian diseases. Despite these management practices, the drop in egg production and increased mortality raised serious concerns about the flock's health status, prompting the farmer to seek veterinary assistance. A comprehensive investigation into the flock's environmental and management conditions revealed adherence to standard practices, with no significant deviations detected. Despite this, the clinical signs observed, in conjunction with the flock's age and dietary profile, suggested a potential metabolic or nutritional imbalance, particularly one affecting energy metabolism.

DIAGNOSTIC PLAN

To investigate the sporadic mortalities in the flock, a comprehensive diagnostic approach was implemented. The process began with a farm visit, during which a detailed assessment of the flock's environment, feeding regimen, and management practices was conducted.

Housing conditions were evaluated for potential contributory factors, while the quality and composition of the feed, along with the delivery systems and intake patterns were analyzed. A thorough clinical examination followed, where individual birds were observed for physical signs and behavioral abnormalities, including general performance, feather condition, comb and wattle coloration, activity levels, and egg production characteristics. Next, necropsy procedures were performed on 11 randomly selected fresh carcasses to identify any gross pathological changes.

This included a detailed examination of the abdominal cavity, internal organs, and tissues to detect abnormalities potentially associated with cause of mortalities. During the necropsy, tissue samples from the liver, along with other relevant organs as considered necessary, were harvested from all 11 carcasses and subjected to histopathological analysis.

OBSERVATIONS AND RESULTS

The farm management practices observed included the use of well-maintained battery cages, which minimized contamination of feed and water (Figure I). Birds were fed a fortified mixture, particularly benefiting those in the first row. However, the confined housing appeared to reduce the birds' activity levels, potentially predisposing them to metabolic imbalances. Clinically, the flock exhibited signs such as pale combs and wattles, indicative of anemia or metabolic stress, along with the production of undersized eggs with poor shell quality, pointing to calcium metabolism

issues. Sporadic mortality and lethargy further suggested underlying systemic illness or metabolic disturbances.

Post-mortem examinations revealed significant pathological changes, including excessive fat deposition in the abdominal cavity and around the pericardium (Figure IIa), enlarged and friable livers with extensive hemorrhagic lesions (Figure IIb and Figure III), and internal hemorrhages in the peritoneal cavity with localized blood clots. The ovarian follicles showed fatty infiltration and hemorrhagic changes in the egg follicles (Figure Va), with some ruptured egg materials observed (Figure Vb).

These findings collectively indicate a strong correlation between the observed clinical signs, gross pathological changes, and the diagnosis of Fatty Liver Hemorrhagic Syndrome (FLHS) in the affected flock.

DIFFERENTIAL DIAGNOSIS

Several differential diagnoses were considered and systematically ruled out based on clinical presentation, laboratory investigations, and pathological findings. Potential infectious diseases such as Newcastle Disease, Avian Influenza, and infectious bronchitis were excluded due to the absence of characteristic signs such as respiratory distress, high mortality rates, and specific lesions associated with these conditions.

Nutritional deficiencies, including Vitamin E and selenium deficiency, were eliminated as plausible causes following analysis of feed composition, which demonstrated sufficient levels of essential nutrients. Furthermore, high xanthophyll pigment levels, which could lead to liver discoloration, were ruled out based on the absence of exaggerated pigmentation in the liver tissues and the lack of associated clinical signs such as decreased egg yolk pigmentation. Collectively, the clinical signs, including lethargy, decreased egg production, and the presence of pale combs and wattles, alongside postmortem findings of enlarged, friable, yellowish livers with evidence of hemorrhage, strongly pointed to Fatty Liver Hemorrhagic Syndrome (FLHS) as the tentative diagnosis.

CONFIRMATORY DIAGNOSIS

Histopathological examination confirmed the tentative diagnosis of FLHS. Key findings included hepatic lipidosis, sinusoidal congestion, and hemorrhagic necrosis.

1. Figure VI highlights marked fatty infiltration in the liver (H&E stain, X100). The photomicrograph shows diffuse lipid vacuoles, a hallmark of hepatic lipidosis, confirming significant metabolic imbalance.
2. Figure VII shows vacuolated hepatocytes with displaced nuclei, as well as areas with darker nuclei and pinkish cytoplasm (H&E stain, X400). These features confirm severe lipidosis and associated tissue damage, hallmark indicators of FLHS

MANAGEMENT INTERVENTIONS

In response to the clinical findings, the affected birds were moved to deep litter housing to promote exercise (Figure VIII). This measure was implemented to address the sedentary lifestyle contributing to metabolic imbalances.

MANAGEMENT AND FOLLOW-UP

The feed was reformulated to lower the levels of fats and carbohydrates, reducing the substrate availability for excessive hepatic lipid deposition. Lipotropic agents, including choline, biotin, Vitamin E, Vitamin B12, and inositol, were incorporated into the diet to enhance lipid metabolism and prevent hepatic fat accumulation. A multivitamin supplement (Amino Power®) was also introduced to improve overall metabolic health and strengthen the birds' resilience to stress.

Ventilation within the poultry house was significantly improved, reducing ambient temperature and enhancing air circulation.

To encourage movement and prevent excessive fat deposition, a subset of birds was transitioned to deep litter housing. This adjustment was aimed at promoting natural behaviors such as scratching and pecking, which support physical activity and energy expenditure. The implemented management strategies led to a significant reduction in mortality rates, bringing losses to a negligible level. Over the two-week follow-up period, only two mortalities were recorded, after which no further deaths occurred. Prior to the intervention, daily mortality was elevated (though exact figures were not recorded), highlighting the effectiveness of the interventions in reducing losses by over 95%.

Egg production exhibited a steady upward trend, marked by noticeable improvements in both the size and number of eggs laid. The farmer reported a gradual increase in production, reaching approximately 50.1%, with a consistent daily increment thereafter.

This progressive recovery highlights the birds' positive response to the implemented management practices, emphasizing their return to normal productivity levels over time. The normalization of comb and wattle pigmentation from pale to healthy red served as an external indicator of recovery, reflecting the restoration of systemic health and hepatic function. These outcomes validated the effectiveness of the combined nutritional and environmental management strategies in addressing FLHS.

DISCUSSION

Fatty Liver Hemorrhagic Syndrome (FLHS) is a multifactorial metabolic disorder that significantly impacts the health and productivity of high-performing layer flocks. The condition is primarily characterized by hepatic lipidosis,

vascular fragility, and subsequent hemorrhage. Our findings resonate with the existing literature, which identifies excessive fat deposition as a hallmark of FLHS (Rozenboim *et al*., 2016; Peng *et al*., 2019; Huang *et al*., 2022). However, the role of lipotropic agents in hepatic lipid mobilization and reducing fat deposition deserves further exploration. Studies by Khosravinia *et al*. (2015) and Onel *et al*. (2017) emphasize that supplementation with lipotropic agents such as choline chloride, biotin, and lecithin significantly decreases hepatic lipid concentrations, thereby reducing the risk of FLHS. Notably, studies like that of Beheshti Moghadam *et al*. (2021) demonstrated the efficacy of methionine and choline supplementation in enhancing lipid stability and production performance in laying hens, highlighting the value of targeted nutritional interventions.

Figure I: Birds intensively reared in battery cages on the commercial layers farm. The housing arrangement emphasizes hygiene but limits physical activity, which may contribute to metabolic disorders such as FLHS

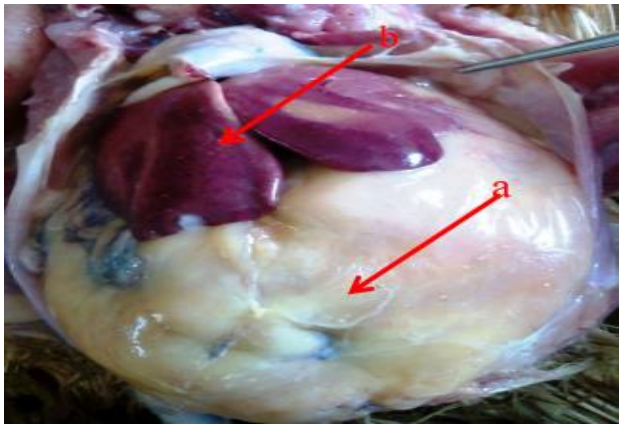

Figure II: Post-mortem findings: (a) Extensive fat deposition in the abdominal cavity and (b) swollen and hemorrhagic liver. These findings support the diagnosis of FLHS

The physiological basis of FLHS lies in the metabolic imbalance caused by high dietary energy and restricted physical activity. Walzem *et al*. (1993) demonstrated that overfeeding disrupts lipid metabolism, increasing liver lipogenic enzyme activity and predisposing birds to hepatic rupture. Similarly, our case revealed that the high-energy diet fed to the 57-week-old flock contributed to lipid synthesis, exacerbating hepatic lipidosis. Low-protein, high-energy diets, as highlighted by Hu *et al*. (2024), can lead to lipid metabolism disorders, characterized by increased triglycerides, total cholesterol, and enhanced expression of hepatic lipogenesis genes. This aligns with our observations and stresses the need for a balanced dietary formulation. Dietary interventions, such as incorporating *pantothenic acid (vitamin B5)* and vitamin B2 as suggested by Hu *et al*. (2024), could potentially mitigate these imbalances.

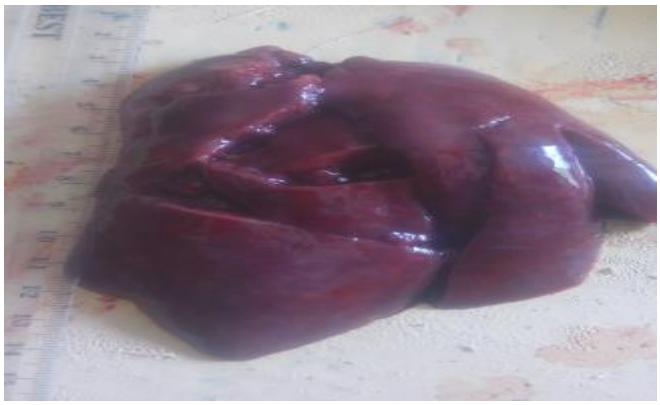

Figure III: Enlarged and hemorrhagic liver, showing typical pathology consistent with FLHS

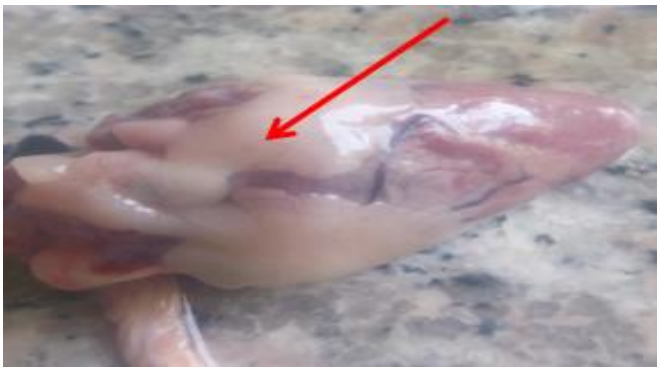

Figure IV: A heart with increased coronary fat consistent with FLHS

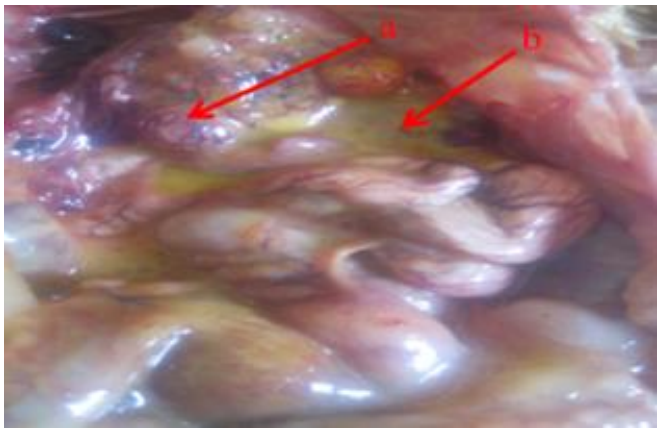

Figure V: (a) Haemorrhagic, distorted ovarian follicles; (b) ruptured egg materials. These abnormalities suggest metabolic stress linked to FLHS

Additionally, findings by Kim *et al*. (2022) suggest that while high-energy diets may not compromise egg production, they reduce feed intake and alter lipid metabolism. Similarly, Han *et al*. (2023) demonstrated that diets with normal metabolizable energy (ME) but higher neutral detergent fiber (NDF) concentrations could reduce hepatic fat and fatty acid synthesis gene expression. These insights highlight the potential of dietary fiber and appropriate energy levels in mitigating FLHS in aged layers.
The susceptibility of older, high-performing hens to FLHS aligns with findings by Ramadan *et al*. (2021), which highlight the dual burden of egg production demands and limited hepatic lipid mobilization capacity. Moreover, systemic stressors, including heat stress, exacerbate oxidative stress pathways, further challenging hepatic function (Emami *et al*., 2020; Onagbesan *et al*., 2023; Kwon *et al*., 2024). Environmental factors, particularly high ambient temperatures during summer months, have been reported to increase FLHS incidence (Samir *et al*., 2019). Although heat stress was not directly measured in this case, improved ventilation and temperature regulation were critical in alleviating these potential stressors. The protective role of antioxidants, as described by Ferramosca *et al*. (2017), could further provide therapeutic avenues to address hepatic oxidative damage.

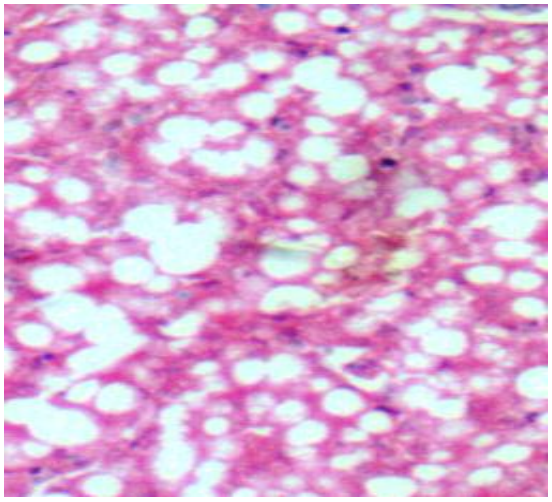

Figure VI: Photomicrograph of liver tissue showing marked fatty infiltration. This microscopic evidence is essential for diagnosing FLHS; (X100, H and E)

Clinical signs observed in this case—pale combs, lethargy, reduced egg quality, and sudden deaths—are consistent with hepatic dysfunction and anemia secondary to hemorrhage, as reported by Shini *et al*. (2020) and Anene *et al*. (2023). Necropsy findings, including friable livers with lipid vacuolation and sinusoidal congestion, corroborate prior descriptions by Schlageter *et al*. (2014) and Trott *et al*. (2014).

These findings reaffirm the importance of histopathology in distinguishing FLHS from other hepatic diseases.

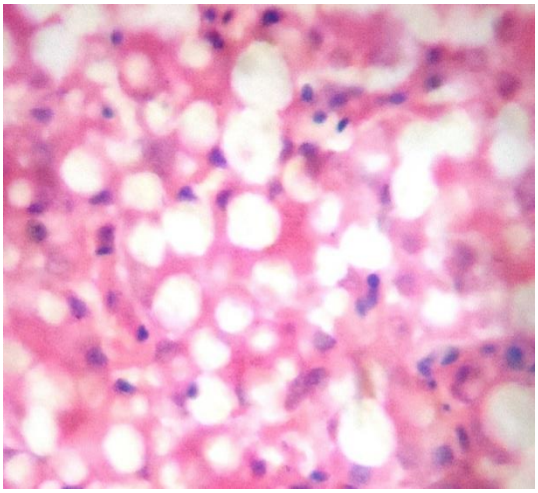

Figure VII: Photomicrograph (X400, H and E) of liver tissue under higher magnification, showing vacuolated hepatocytes and disrupted hepatic architecture, corroborating the diagnosis of FLHS

Figure VIII: Birds from the affected cage were transitioned to deep litter rearing to encourage physical activity and mitigate metabolic stress.

Comparison with previous studies further highlights the multifactorial nature of FLHS. Trott *et al*. (2014) questioned the role of lipidosis, suggesting that hepatic rupture and hemorrhage could occur in the absence of severe lipidosis. This contrasts with our findings, where marked hepatic lipidosis was observed, aligning more closely with Rozenboim *et al*. (2016) and Shini *et al*. (2020). Additionally, Agunos *et al*. (2006) and Samir *et al*. (2018) reported *Escherichia coli* isolation in FLHS-affected birds, raising questions about bacterial involvement in pathogenesis.

While colisepticemia was ruled out in our case due to the absence of significant bacteriological findings, its potential role warrants further investigation.

The dietary intervention implemented in this case, which included lipotropic agents and multivitamin supplementation, led to significant improvements in clinical outcomes. Studies by Yang *et al*. (2017) and Hailegebreal *et al*. (2022) support the efficacy of such interventions in improving hepatic lipid profiles and overall metabolic health. Reduced mortality rates and improved egg production in our flock validate the integrated management approach adopted. Furthermore, the transition to deep-litter housing aligns with findings by Shini *et al*. (2019), which highlight the protective effects of alternative housing systems in mitigating FLHS.

The integration of neutral detergent fiber (NDF**)** in normal-energy diets, as suggested by Han *et al*. (2023), and polyunsaturated alkyl-β-ketone, a Polysaccharide prepared from Atractylodes macrocephala Koidz (PAMK) supplementation for regulating hepatic lipid metabolism (Miao *et al*., 2021) could provide additional layers of dietary support. Moreover, reducing reliance on chelated minerals, as proposed by Branton *et al*. (1995), may also mitigate FLHS risk in commercial layer flocks.

The rapid improvement in clinical signs, egg production, and reduced flock mortality observed in this case underscores the effectiveness of an integrated management approach. Mortality rates declined to negligible levels within two weeks, while egg production steadily recovered, consistent with findings from previous studies demonstrating that targeted nutritional and management strategies can significantly mitigate the performance deficits associated with FLHS (Hailegebreal *et al*., 2022).

Our case aligns with earlier reports of FLHS in high-performing layer flocks, which emphasize the complex interaction between nutritional and management factors in disease development. Studies by Khan *et al*. (2021) and Yaqoob *et al*. (2024) documented the effectiveness of lipotropic agents in alleviating FLHS, while van der Windt *et al*. (2018) and Li *et al*. (2024) highlighted the critical role of physical activity in reducing hepatic fat accumulation. The outcomes of this case add to the growing evidence supporting the use of integrated approaches for managing metabolic disorders in poultry.

Studies have further shown that inadequate physical activity in caged systems predisposes hens to FLHS (Shini *et al*., 2019; Hansen and Walzem, 1993).

The transition to deep-litter housing in our flock aimed to mitigate these effects by encouraging natural behaviors and physical activity, consistent with the recommendations of van der Windt *et al*. (2018).

The findings further highlight the importance of proactive management in addressing FLHS in commercial flocks, especially those under high-intensity production systems. The success of the interventions underscores the necessity of balancing dietary energy with essential nutrients, actively monitoring flock metabolic health, and implementing environmental modifications to minimize stress. These results have broader implications for poultry production by demonstrating how targeted interventions can simultaneously improve bird welfare and economic performance. Overall, this case illustrates the value of a holistic approach to FLHS management that incorporates nutritional, environmental, and husbandry strategies. The findings align with broader research advocating for proactive measures to address the metabolic and environmental risk factors underlying FLHS. Future studies investigating the interplay of nutrition, housing, and genetic predisposition could offer deeper insights into the pathogenesis and effective management of this multifaceted condition.

CONCLUSION

Fatty Liver Hemorrhagic Syndrome (FLHS) is a critical metabolic disorder that poses significant risks to the productivity and welfare of commercial layer hens. This case study presents a comprehensive investigative approach to diagnosing and managing FLHS in a flock of Isa Brown laying hens in Maiduguri, Nigeria. By utilizing clinical, pathological, and histopathological evaluations, the case highlights the importance of employing a combination of diagnostic tools for accurate diagnosis.

Key findings such as excessive hepatic fat deposition, liver fragility, and hemorrhagic lesions align with typical manifestations of FLHS. The underlying contributory factors, including a high-energy diet, limited physical activity, and suboptimal housing conditions, were identified. Through targeted nutritional adjustments and environmental modifications, we demonstrated the efficacy of a multifaceted intervention strategy that led to improved flock health, reduced mortality, and enhanced egg production.

This case highlights the importance of proactive management strategies in commercial poultry operations to prevent and mitigate the risks associated with metabolic disorders like FLHS. The intervention approaches used here—ranging from nutritional adjustments to environmental improvements—can be generalized to other commercial poultry farms facing similar challenges. Furthermore, the role of veterinary oversight is critical in diagnosing and managing complex health issues, ensuring the sustainability and profitability of poultry production systems.

RECOMMENDATIONS

To effectively manage and prevent Fatty Liver Hemorrhagic Syndrome (FLHS) in high-performing layers, several key recommendations are proposed. Nutritional management should involve regularly evaluating and optimizing poultry feed formulations to balance energy levels, thereby reducing metabolic disorders. Including lipotropic agents such as choline, biotin, Vitamin E, Vitamin B12, and inositol in diets is advised as a preventive measure against hepatic lipidosis. Additionally, promoting physical activity through alternative housing systems like deep litter or outdoor runs can reduce fat deposition by encouraging natural behaviors and energy expenditure. Ensuring optimal housing conditions, particularly with ventilation and temperature control, is crucial to minimize heat stress and its metabolic effects.Routine health monitoring and early intervention are critical in farm management to detect early signs of FLHS and other metabolic conditions. Regular health assessments, nutritional audits, and swift veterinary responses to any health deviations are essential for minimizing flock losses. Further research should be conducted to explore the long-term efficacy of dietary and physical activity interventions. Moreover, training programs and workshops for farmers on recognizing and managing metabolic disorders should be emphasized to promote best practices. Implementing these strategies will enhance flock health, support sustainable poultry production, and reduce economic losses associated with metabolic disorders like FLHS.

Conflict of interest

The authors declare that they have no competing interests.

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