Tibial Dyschondroplasia of Poultry

Subjects: Veterinary Sciences

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Tibial dyschondroplasia (TD) is a metabolic disorder that impairs bony and cartilage processes. It is common in broilers due to the consumption of thiram, especially in the industrial and agriculture zones.

poultry tibial dyschondroplasia thiram apoptosis

1. Introduction

Cellular and molecular pathways regulate bone formation and growth. Any variation from the normal process may result in bone abnormalities, which pose a significant economic challenge to the poultry business [1]. The control of bone formation and growth seems complicated, with several layers of interaction between the regulatory factors [2]. Chondrocytes' formation and differentiation occur on the growth plate in a particular region. Pre-hypertrophic chondrocytes form a columnar layer once proliferating chondrocytes stop replicating. These phases are determined by the cellular phenotype and extracellular matrix metalloproteinase (ECM) proteins. Columnar cells, pre-hypertrophic cells, and hypertrophic cells express distinct transcription factors and ECM proteins as they progress through the embryonic stages [3]. As a result, interactions between these essential processes in the growth plate become necessary for appropriate long bone development [4].

Tibial dyschondroplasia is among the remarkably prevailing skeletal abnormalities affecting young poultry birds [5]. The prevalence of this tibiotarsal bone condition has increased by 30% in the flock at broiler farms. Due to the majority of its symptoms being sub-clinical [6], it is often difficult to adequately detect the prevalence of TD at these farms; as a result, farmers frequently find it easy to let their guard down. In fact, broilers with TD experience leg weakness, limited motion, and even walking difficulties. Broilers are more likely to sustain fractures during the feeding process, which negatively impacts the welfare of the birds and reduces production, which further causes significant financial loss for the poultry industry. Various researchers worldwide have constantly focused on the etiology and prevention of TD [7][8]. In most cases, nutritional, ecological, and genetic factors have been implicated in its etiology [9]. For instance, soybean meal in feeding has been associated with TD pervasiveness, along with further concerns, including ergocalciferol insufficiency, hyperthyroidism (overactive thyroid), and abnormal levels of biological parameters such as interleukin-1β and nitric oxide [10]. Moreover, according to some studies, copper deficiency, fusarochromanone, excessive dietary levels of cysteine and homocysteine, metabolic acidosis [11], vitamin D deficiency [12], disbalance of calcium and phosphorus [13], and thiram contamination [14] may also cause the condition. The condition of TD has been linked to aberrant ossification and prolongation of tibial growth plates

(GP) as a result of reduced chondrocyte propagation and differentiation [15]. An ideal cartilage matrix has enough blood supply and mineralization; however, this is not always the case for TD [16]. During TD conditions, chondrocytes are premature and more prominent than usual because of pre-hypertrophic enlargement with avascular ossein zones in cartilage [17].

Pesticides are widely used in agriculture to eradicate or control many agricultural bugs, herbicides, and diseases that may harm crops and animals. On the other side, pesticides have become a hazard due to their toxicity. Living organisms may be exposed precisely or periphrastically over the food chain, air, soil, and water [18]. Thiram (Tetramethyl thiuram disulfide) is a dithiocarbamate pesticide and fungicide commonly used in horticulture to treat grains for seed protection and preservation [19]. It has a lipophilic character that can effortlessly combine with cell membranes to induce cytotoxicity, bone formation problems, cartilage damage, and immunological downturns. It may also cause membrane disruption, bone biosynthetic pathway inactivation, and angiogenesis inhibition [20]. So, it is highly associated with the induction of TD, with symptoms that resemble commonly occurring tibial dyschondroplasia. Additionally, earlier research has shown that TH (thiram) may cause TD in chickens at the dose rate of 50 mg/kg [5][21]. Moreover, it has been frequently mobilized to imitate TD in numerous research trials [22][23][24][25].

2. Growth Plate Associated Tibial Dyschondroplasia in Poultry

During TD condition, the chondrocytes in the growth plate region are unorganized, having fewer blood vessels with lesions in proliferative and hypertrophic zones [26]. These lesions include avascular, noncalcified tissue and soft cartilage. Histologically, hypertrophic zone enlarges and combines with avascular cartilage zones [17]. Thiram is highly associated with the induction of TD, with symptoms resembling tibial dyschondroplasia (**Figure 1**). Additionally, earlier research has shown that TH (Thiram) may cause TD in chickens. Moreover, it has been frequently mobilized to imitate TD in numerous research trials [14][22][27]. The prior studies indicate that thiram induces apoptosis in chondrocytes, raising the number of apoptotic chondrocytes inside the osteogenesis area [28][29]. Besides, thiram inhibits angiogenesis within the GP, reducing chondrocytes function and osteogenesis [23][26].

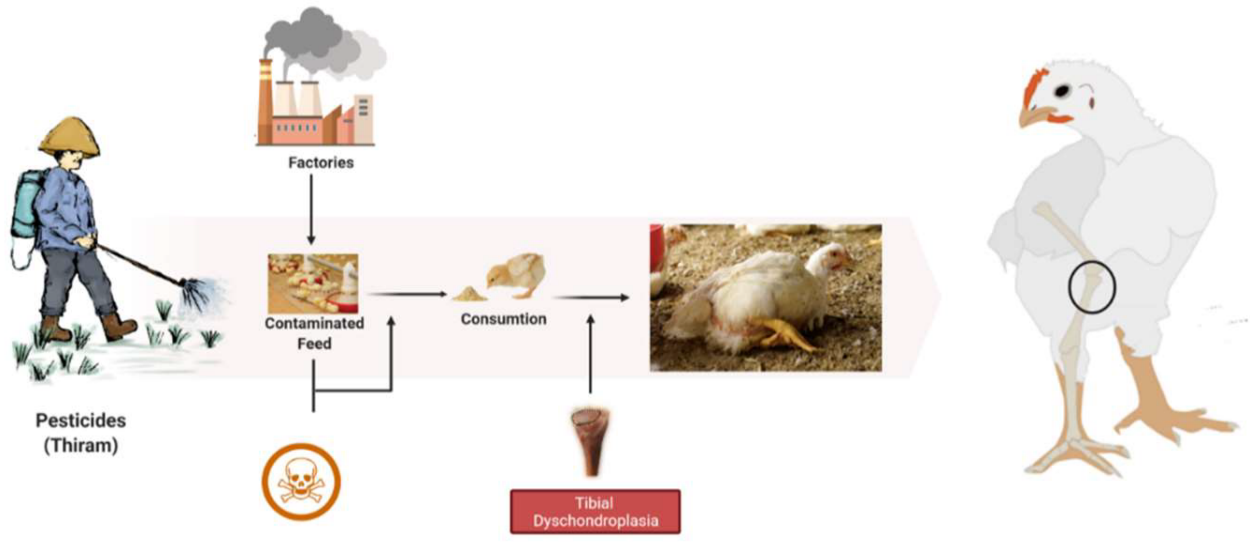

Figure 1. The root cause of tibial dyschondroplasia in broilers.

3. Prevention and Treatment against Apoptotic Events of TD

According to the previous studies, chlorogenic acid (CGA) in the feed may lower the prevalence of tibial dyschondroplasia as it targets specific mediators related to apoptotic events [12][28][29][30][31]. CGA is the most abundant phenolic acid in nature, being synthesized when quinic and caffeic acids are esterified. It occurs naturally in various fruits, herbs, and vegetables, including kiwi fruit, coffee beans, tobacco leaves, and honeysuckle [32]. It has been seen in pharmacological trials to have significant antioxidant, anti-inflammatory, antiviral, anticancer, cardioprotective, anti-apoptotic, and free radical scavenging properties [28][29][33][34]. Zhang et al. discovered that CGA might stimulate osteoblast growth and speed the S phase transition process. Additionally, it may promote Bcl-2 expression and limit Bax activation during apoptosis, ultimately decreasing osteoblast apoptosis [35]. It has been shown in recent work by Kulyar et al. that CGA has therapeutic benefits for TD chickens by modulating a variety of pathways associated with apoptosis and inflammasome [28][29]. Furthermore, targeting micro RNAs is a better therapy for overcoming such disorders. It is well known that miRNAs control mRNA expression via binding to their 3′-UTRs. These microRNAs (miRNAs) convoluted in various skeletal buildup aspects [36][37][38]. Such miRNAs attach to complemental bases in 3′ untranslated part of particular target mRNAs, preventing the production of specific proteins [39]. The major biological actions such as cell proliferation, apoptosis, cell differentiation, and metabolism are influenced by miRNAs. As a result, miRNA expression alterations may significantly impact normal and abnormal cells [40]. The miR-460a is an essential micro RNA involved in many structural and metabolic cellular processes [41]. Moreover, it is correlated with inflammatory genes, including IL-1β, in broiler chickens [41][42]. Some other options can be used from the treatment perspective (**Table 1**).

Table 1. Alternative treatment options for controlling apoptotic events in tibial dyschondroplasia.

Name	Active Components	References
Morinda officinalis	Iridoids glycoside	[43]

Name	Active Components	References
Resveratrol	Phytoalexin, polyphenolic	[44]
Hesperetin	Flavonoids	[45]
Angelica	Ferulic acid, butylidenephthalide, and polysaccharides	[46]
Tetrandrine	Alkaloids	[47]
Puerarin	Isoflavone	[48]
Berberine II	Alkaloids (Isoquinoline)	[49]
Sophoridine	Matrine	[50]
Bauhinia championii flavone	Flavonoids	[51]
Achyranthes bidentata	Phytosterone, phytoecdysteroids, saccharides and saponins	[52]
Sinomenine	Alkaloids	[53]

Recent research has focused on the idea that, in contrast to pro-apoptotic, the anti-apoptotic approach in tibial dyschondroplasia may occasionally be advantageous as it reduces the inflammatory response [29]. In fact, an earlier regulation of apoptosis may be beneficial for chondrocytes' survival. Moreover, local and international industries adopt a proper nutritional strategy for preventing tibial dyschondroplasia (e.g., a proper ratio of calcium, phosphorus, and vitamin D [54][55]) and vaccination for other bone disorders, e.g., viral and bacterial arthritis, chondronecrosis, osteomyelitis, etc. [56][57].

These findings provide fresh knowledge to researchers. Even though several significant research studies have contributed to a deeper understanding of the treatment and prevention of tibial dyschondroplasia, the knowledge is still inadequate for such a critical issue. As a result, the discovery of effective and very sound therapy is urgently required. Moreover, future research on the mechanism of protein-to-protein interaction with the latest scientific findings may lay the foundation for associated bone disorders, e.g., osteoarthritis and osteoporosis.

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