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The Influences of a Dietary Phytobiotic *"Yucca schidigera"* Supplementation on Poultry: An Updated Article Review

Review Article

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ABSTRACT

Over the last decade, antimicrobials have been banned as growth promoters and replaced by other natural alternatives. Plant-based poultry feed additives and herbal extracts have been effectively used in poultry worldwide. One of these feed additive phytogenic substances is *Yucca schidigera* (YS), which showed various beneficial effects in livestock production, including poultry. This article provides a comprehensive understanding of YS's overall benefits. The various influences of YS supplementation on performance parameters of broilers, layers, and breeders, as well as carcass traits, intestinal health, immunity, and blood metabolites, and its properties as an antioxidant, anti-inflammatory, and anti-stress agent in poultry, were reviewed and updated. The dietary supplementation of YS in broilers could improve the feed intake, body weight, feed conversion ratio, as well as dressing and carcass percentage and weight. In layers and breeders, YS could enhance the egg production parameters, fertility, and hatchability, respectively. An enhanced intestinal integrity, a decreased pathogenic bacterial load, and an increased beneficial bacterial count were observed after adding YS to the diets of different poultry species. Moreover, YS showed boosting of the bird's humoral immune response and stimulation of the important liver and kidney metabolites. Besides, it acts as an effective antioxidant, anti-inflammatory, and anti-stress dietary supplement for poultry production systems. In conclusion, dietary YS is the best option for the overall poultry production parameters and can be used as a good natural growth-promoting antimicrobial alternative.

KEY WORDS antioxidant, blood metabolites, immunity, intestinal health, performance, poultry, *Yucca schidigera*.

INTRODUCTION

Although antimicrobials have played a crucial role in preventing infection as well as promoting animal production, the food and drug safety organizations restricted their use in livestock production due to their adverse effects on the development of antimicrobial resistance, thereby posing a potential threat to human health (Saleh *et al*. 2020). Therefore, it is urgent to search for antimicrobial alternatives with no adverse health effects. Over the last few decades, plant-derived extracts, which are natural bioactive compounds, have been widely and effectively used as antibiotic alternatives in livestock production and veterinary medicine (Lillehoj *et al*. 2018; Abd El-Ghany, 2024; Abd El-Ghany, 2025). Phytogenics may provide a viable alternative to conventional antimicrobials, contributing to improved sustainability and animal welfare in the poultry industry (Abd El-Ghany and Eraky, 2019; Abd El-Ghany, 2020a; Abd El-Ghany, 2020b; Abd El-Ghany, 2022; Abd El-Ghany and Babazadeh, 2022).

Yucca schidigera (YS) (Agavaceae), commonly known as *Yucca*, is a plant in the family Liliaceae native to southwestern United States and northern Mexico deserts as well as China (Cheeke *et al*. 2006; Kucukkurt *et al*. 2016). It has

been recognized by indigenous Indians as a source of food and drugs due to its health-promoting effects (Patel, 2012). Abd Elmoteleb *et al*. (2024) reported that YS is a safe, effective, biocompatible, and cost-efficient alternative natural product. The extracts and powder of YS have been widely used in the food industry as a natural additive and flavor enhancer, while in the livestock industries, YS is used as a natural antimicrobial feed additive (Cheeke, 2000; Alghirani *et al*. 2021; Abd Elmoteleb *et al*. 2024). In humans, the plant has been used to relieve joints' pain, stop bleeding and diarrhea, and treat skin ulcers (Patel, 2012). A variety of phytochemical substances, including steroid saponins, poly-phenols, glycol, and resveratrol, are extracted from YS (Oleszek *et al*. 2001; Piacente *et al*. 2005). The plant is known as one of the main sources of saponins. Steroidal saponins are accounted for approximately 10% of the dry weight of YS stem. Saponins are present in YS extracts in a steroidal form with strong antibacterial properties. Interestingly, the polyphenolic compounds existing in YS, such as resveratrol and a number of other stilbenes (*Yucca* oils A, B, C, D, and E), have antimicrobial, antioxidant, immunomodulatory, anti-inflammatory, anti-carcinogenic, and health-promoting activities (Cheeke *et al*. 2006; Ashour *et al*. 2014). Moreover, the use of saponins from both *Quillaja saponaria* and YS showed strong immune modulatory and gut health benefits, offering valuable alternatives to traditional antibiotics (Saddoris-Clemons *et al*. 2024). *Yucca* powder and juice are used to decrease the fecal odors, ammonia, hydrogen sulfide, and some other harmful volatile compounds in domestic animal excreta (Kelly and Kohler, 2003; Gaber, 2006; Pen *et al*. 2006; Liang *et al*. 2009; Chrenková *et al*. 2012). The promising properties of *Yucca* have led to several cutting-edge studies on its use in broiler chickens' nutrition.

Feed or water supplementation of YS powder or extracts is suitable and has many benefits for poultry (Table 1). The profit per bird and benefit-cost ratio were improved after water treatment of broilers with YS (Sariozkan *et al*. 2015; Patoary *et al*. 2020). Besides, the extracts of YS have been effectively used as growth promoters (Alghirani *et al*. 2021; Dai *et al*. 2023; Sun *et al*. 2023; Mert, 2025) and showed immuno-stimulatory (Ranjbar *et al*. 2014; Su *et al*. 2016; Sun *et al*. 2017; Dai *et al*. 2023; Mert, 2025), antioxidant (Alagawany *et al*. 2016; Alagawany *et al*. 2018; Farag *et al*. 2018; Mao *et al*. 2023; Abd Elmoteleb *et al*. 2024), antimicrobial (Matusiak *et al*. 2016; Dai *et al*. 2023; Abd Elmoteleb *et al*. 2024), anti-inflammatory (Cheeke *et al*. 2006; Oelschlager *et al*. 2019; Mao *et al*. 2023; Saddoris-Clemons *et al*. 2024), anti-protozoa (Alfaro *et al*. 2007; Oelschlager *et al*. 2019; Bafundo *et al*. 2020; Kozłowski *et al*. 2022; Mao *et al*. 2023; El-Sawah *et al*. 2025), and anti-stress properties (Luo *et al*. 2022). Besides, YS extracts have proved to improve many physiological functions, including lipid and protein metabolism (Gupta, 2014; Alagawany *et al*. 2016). YS could also be used to reduce ammonia emissions from poultry farms due to the presence of glycol (Tsukahara and Ushida, 2000; Cabuk *et al*. 2004; Chepete *et al*. 2012; Vlčková *et al*. 2017; Saeed *et al*. 2018; Dai *et al*. 2023; Munezero *et al*. 2023); thus, this might help in enhancing the performance parameters. Figure 1 shows the different influences of YS on the birds' bodies. The variable modes of action of YS in the birds' bodies are illustrated in Figure 2. It is noteworthy to mention that supplementation with *Yucca* not only enhances general health but also supports environmental sustainability in the modern poultry industry (Mert, 2025). In particular, the reduction in ammonia emission is a vital factor that improves both animal welfare and environmental impacts (Alfaro *et al*. 2007).

The current review article was thus planned to explore the various influences of YS supplementation on performance parameters of broilers, layers, and breeders, as well as carcass traits, intestinal health, immunity, and blood metabolites, and its properties as an antioxidant, anti-inflammatory, and anti-stress agent in poultry.

Performance parameters

The productive performance parameters are a critical metric for assessing poultry production. The effective nutrient digestion and absorption are crucial for the growth promotion, productivity, and the general health of animals.

YS plays a significant role in promoting growth and production performance in the poultry industry sector (Malecki *et al*. 1995; Preston *et al*. 1999; Cheeke and Otero, 2005; Patel, 2012; Su *et al*. 2016; Saeed *et al*. 2018). Previous studies showed that dietary supplementation with YS increased the body weight (BW), ameliorated the average daily body weight gain (BWG), and improved the feed conversion ratio (FCR) of broilers (Alfaro *et al*. 2007; Ranjbar *et al*. 2014; Sahoo *et al*. 2015; Sun *et al*. 2017; Amirbeik *et al*. 2018; Awad *et al*. 2021; Bafundo *et al*. 2021; Dai *et al*. 2023) and egg parameters in layers (Dziuk *et al*. 1985; Kutlu *et al*. 2001; Kaya *et al*. 2003; Ayasan *et al*. 2005; Tugay *et al*. 2005; Wang and Kim, 2011; Alagawany *et al*. 2016; Alagawany *et al*. 2018; Khaskheli *et al*. 2020; Al-Fehaid *et al*. 2022). The early study of Baker (1997) reported that broilers treated with YS extract along with aluminium chloride showed improved live BW, while the feed intake (FI) was not affected. Obianwuna *et al*. (2024) demonstrated that mixtures containing YS increased live BWG in broiler chickens by up to 10%. Besides, Dai *et al*. (2023) showed that the different levels of *Yucca* spp. combinations have variable effects on BWG, and determining the optimal dosage is critical.

Table 1 *Yucca schidigera* (YS) dietary inclusion and its effect on avian species

Inoculation rate	Bird spp.	Effects[1]	Reference
YS at 63 ppm/kg diet	Broiler chickens	✓ Improved BW	Johnston *et al.* (1981)
60 or 120 ppm YS	Broiler chickens	✓ Increased growth rate and Feed efficiency	Lundeen (2000)
YS powder with a 10.76% saponin concentration at levels of 0, 30, 60, and 120 ppm	Layer chicken hens	✓ No impact on FI, egg yield, feed efficiency, and quality indices of eggs	Kutlu *et al.* (2001)
200 ppm of YS powder	Laying quails	✓ No impact on feed efficiency and egg indices	Kaya *et al.* (2003)
120 mg/kg YS extracts	Broiler chickens	✓ Improved BW ✓ Reduce ammonia concentration in intestine	Cabuk *et al.* (2004)
0.1% YS coccidiostat-treated or vaccinated birds	Broiler chickens	✓ Improved average daily BWG and FCR ✓ Increasing the length of duodenal villi	Alfaro *et al.* (2007)
30, 60, and 120 mg/Kg YS + 120 mg/kg caprylic acid	Layer chicken hens	✓ Improved egg weight and feed efficiency ✓ Reduced serum and yolk cholesterol concentration ✓ Decreased proliferation of *E. coli*	Wang and Kim (2011)
100 ppm of YS extract in diets	Layer chicken hens	✓ Decrease in ammonia generation and emission by 44% and 28% for the first two days of manure storage	Chepete *et al.* (2012)
120 ppm of YS extract in diets	Laying Japanese quail	✓ No effect on egg hatchability, total eggs set, and fertile eggs %	Ayasan (2013)
125 mg/kg YS	Broiler chickens	✓ Improved growth and health performances	Ranjbar *et al.* (2014)
100 mg/kg caprylic acid + 100 mg/kg YS extract	Broiler chickens	✓ Improved BWG, FI, and FCR efficiency ✓ Reduced mortality ✓ Increased bursa of Fabricius and relative organs' weights ✓ Increased white blood cell (lymphocyte) counts ✓ Reduced caecal *E. coli* count ✓ Improved meat quality	Begum *et al.* (2015)
225 mg/kg YS	Broiler chickens	✓ Improved growth and health performances	Sahoo *et al.* (2015)
YS extract up to 100 mg/kg diet	Layer chicken hens	✓ Enhanced egg number, egg mass, and eggshell thickness	Alagawany *et al.* (2016)
100 mg/kg of YS 200 mg/kg of YS	Broiler chickens	✓ Improved feed efficiency ✓ Enhanced antioxidant and immune properties	Su *et al.* (2016)
100, 200, and 300 mg/kg YS extract	Broiler chickens	✓ No significant effect on live BWG, FI, and feed utilization ✓ Increased catalase activity and gene expression ✓ Improvement of liver antioxidant capacity	Sun *et al.* (2017)
0.02% YS powder 0.01% YS powder	Broiler chickens	✓ Improved growth performance ✓ Enhanced IgM production ✓ Decreased low-density lipoprotein concentration in serum ✓ No effect on FI and carcass traits	Amirbeik *et al.* (2018)
0.5 ml YS extract/L drinking water	Broiler chickens	✓ Significant reduction in total aerobic colony count ✓ Insignificant increase in lactic acid bacteria ✓ Increased antioxidant enzyme and IgM and IgG levels ✓ Positive effects on fat oxidation parameters	Ayoub *et al.* (2019)
1 L YS/1000 L drinking water	Broiler chickens	✓ Non-significant difference in drip and cooking losses of breast muscle	Benamirouche *et al.* (2020)
250 mg YS/kg	Broiler chickens	✓ Increased antioxidant levels ✓ Decreased protein peroxidation	Galli *et al.* (2020)
1 ml YS to 20 L drinking water	Broiler chickens	✓ Minimize the ammonia gas emission ✓ Improve carcass quality ✓ Increase production performance	Patoary *et al.* (2020)
100 mg/kg YS extract	Broiler chickens	✓ Improved growth performance, ileal nutrient digestibility, gut health, carcass characteristics, and meat quality	Alghirani *et al.* (2021)
250 g/ton and 500 g/ton YS	Layer chicken hens	✓ Improved egg number, mass, and weight, Haugh unit, shell percentage, shell thickness, and FCR ✓ Boosted cellular immune response	Al-Fehaid *et al.* (2022)
Basal diets containing: 100 mg/kg feed of YS extract. 500 mg/kg feed of caprylic acid 100 mg/kg feed of YS extract + 500 mg/kg feed of caprylic acid 1000 mg/kg feed of caprylic acid 100 mg/kg feed of YS extract + 1000 mg/kg feed of caprylic acid 2000 mg/kg feed of caprylic acid 100 mg/kg feed of YS extract + 2000 mg/kg feed of caprylic acid	Layer chicken hens	✓ Improved BW, FI, FCR, and egg production and egg mass (YS and caprylic acid) ✓ No effect on egg weight, yolk weight, albumin weight, egg shell weight, egg shell thickness, yolk index, shape index, and yolk color ✓ Increased concentration of serum glucose and T3 and T4 hormones ✓ Decreased serum total cholesterol concentrations and H/L ratio	El-Shafei *et al.* (2022)
500 g/T YS 625 g/T (anticoccidial)	Broiler chickens	✓ Improved BW and FCR ✓ Reduced *Eimeria* oocysts/gram count	Kozłowski *et al.* (2022)
0.5, 1, and 1.5 ml YS extract/L drinking water	Broiler chickens	✓ Increased intestinal *Lactobacillus* count	Rahman *et al.* (2023)
250 g/ton *Quillaja Saponaria* and YS	Broiler chickens	✓ No effects on BWG, FI, carcass yield, or blood biochemistry parameters	Alfredo (2023)
Basal diets with *Yucca* saponin (500 mg/kg), YS (500 mg/kg), and *Quillaja Saponaria* (500 mg/kg)	Broiler chickens	✓ Enhanced growth performance, antioxidant and anti-inflammatory activities, and immunity ✓ Improved intestinal health and ammonia metabolism	Dai *et al.* (2023)
500 mg/kg YS in *C. perfringens* and *Eimeria* spp. challenged birds	Layer chicken hens	✓ Improved productive performance and egg quality ✓ Enhanced antioxidant capacity of the jejunum	Mao *et al.* (2023)
YS extract 0.02% and α-1,6-galactosidase and β-1,4-mannanase multi-carbohydrase 0.1%, and low crude protein	Broiler chickens	✓ Improved nutrient digestibility, carcass metrics, and ammonia emission ✓ No effect on growth performance	Munezero *et al.* (2023)
Oral treatment of 5, 10, and 15 mg YS/day	28-day-old pigeons	✓ Improved serum biochemistry, immunoglobulin contents, and intestinal morphology by regulating the composition of microbial community in the ileum	Sun *et al.* (2023)
150 and 300 mg YS extract/kg + 400 and 800 mg basil oil /kg	Broiler chickens	✓ Enhanced meat quality ✓ Improved *Lactobacillus* count	Elmeligy *et al.* (2025)
100 mg YS extract and its nano-emulsion in the drinking water	Broiler chickens	✓ Mitigated the negative effects of *Eimeria tenella* infection (reduced oocyst counts) ✓ Improved BWG and enhanced carcass quality	El-Sawah *et al.* (2025)
Humate (300 mg/kg), YS (100 mg/kg), and their combination (300 mg/kg H + 100 mg/kg Y)	Broiler chickens	✓ Improved growth performance, intestinal microbiota, ileal digestibility, and blood parameters	Mert (2025)

[1] BW: body weight; BWG: body weight gain; FI: feed intake; FCR: feed conversion ratio; *E. coli*: *Escherichia coli*; Ig: immunoglobulin; YS: *Yucca schidigera*; H/L: heterophils/lymphocytes; T3: tri-iodothyronine and T4: thyroxine.

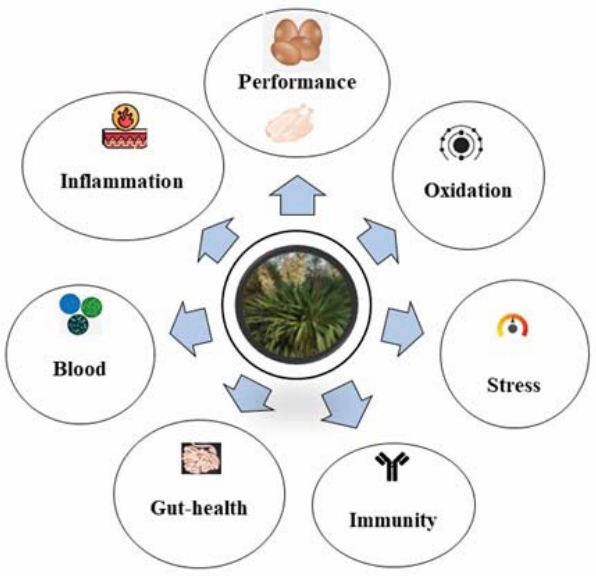

Figure 1 The impact of *Yucca schidigera* on body functions of the birds

It has been reported that supplementation of commercial laying flocks with YS induced a considerable favorable effect on the feed efficacy, performance productivity, finishing BW, and egg weight (Wang and Kim, 2011; Gurbuz *et al*. 2016). Dietary YS also showed positive influences on egg yield parameters and egg shell quality in laying Japanese quails (Ayasan *et al*. 2005). Similarly, Alagawany *et al*. (2018) found that adding YS extract to the feed of Japanese quails increased egg production, FI, and FCR. The results of the recent study of Mao *et al*. (2023) demonstrated that YS treatment of *Clostridium perfringens* (*C. perfringens*) and *Eimeria* spp. challenged layer hens induced an enhancement in the productive performance and egg quality, including increased egg weight, albumen height and weight, and yolk weight. In breeders, Enaiat *et al*. (2009) found that cocks of YS and YS with aluminium chloride treatments had recorded significantly high fertility %.

The growth-enhancing properties of YS are related to regulation of the intestinal microflora, improving nitrogen metabolism, digestion and absorption of nutrients, and intestinal health, as well as the anti-inflammatory, antioxidant, and immuno-modulatory capabilities (Bafundo *et al*. 2021). YS can ameliorate the intestinal morphology and increase the content of short-chain fatty acids (Dai *et al*. 2023). Supplementation with YS increased FI, most likely through reducing the circulation of cholecystokinin in the developing broilers under the stress of high ambient temperatures (Luo *et al*. 2022). Jun-Lin *et al*. (2016) demonstrated that *Yucca* supplementation decreased the intestinal pathogens, increased feed absorption, and improved FCR by 4–6%.

In addition, the YS-treated broilers (87.26%) exhibited higher digestibility compared to the humate-treated group (86.46%), reflecting YS ability to enhance lipid absorption in the intestinal environment (Mert, 2025).

Generally, the favorable impact of phytobiotic feed additives such as YS is attributed to the presence of steroidal saponins, which contribute to the emulsification of oil fats, promotion of their digestion, and absorption of vitamins and minerals, thus improving intestinal health, decreasing microbial pressure, and preventing intestinal pathogens, perhaps leading to improved nutrient digestibility and absorption (Begum *et al*. 2015). Furthermore, steroidal saponins in YS have beneficial effects on the digestive tract through the activation of digestive enzymes, increasing the villus height and penetrability of intestinal mucosal cells, inhibiting the active mucosal transport, and facilitating the uptake of materials that are normally not absorbed (Su *et al*. 2016).

Additionally, supplementation with saponin extracts was found to reduce blood urea concentration, ammonia production, and odours from poultry droppings (Sahoo *et al*. 2015). Saponins are steroidal glycosides that have a strong surfactant activity which reduces the fluids' superficial tension and allows better nutrient absorption by the intestinal epithelium. Saponins can physically bind with ammonia and reduce its amount and emission (Das *et al*. 2012; Ayoub *et al*. 2019; Patoary *et al*. 2020). Besides, saponins increase the nutrients' absorption by decreasing the intestinal surface tension and activating the intestinal villi development, so they have a positive influence on performance indices (Jun-Ling *et al*. 2016). It has also been found that saponins may increase intestinal permeability and facilitate fat absorption (Cheeke, 2000), which may be attributed to an increased surface area of intestinal villi or modulation of microbial activity (Patoary *et al*. 2020).

The polyphenol compound present in YS also plays an important role due to its anti-inflammatory, antimicrobial, antioxidant, and free-radical-hunting characteristics, as well as its immune-enhancing properties, all of which enhance the growth performance of broilers (Su *et al*. 2016).

However, the performance parameters were not affected by adding YS to the diets of layers (Guclu, 2003; Kaya *et al*. 2003; Guclu and Iscan, 2004; Chepete *et al*. 2012; Ayasan, 2013; Sun *et al*. 2023) or broilers (Yeo and Kim, 1997; Cabuk *et al*. 2004; Begum *et al*. 2015). This variation may be due to the difference in the used breeds or species of poultry, the type of diet, and low levels of saponins (2.7%) and phenolic compounds (0.8%) that could not improve digestion, absorption, and nutrient utilization in the gut (Alagawany *et al*. 2016).

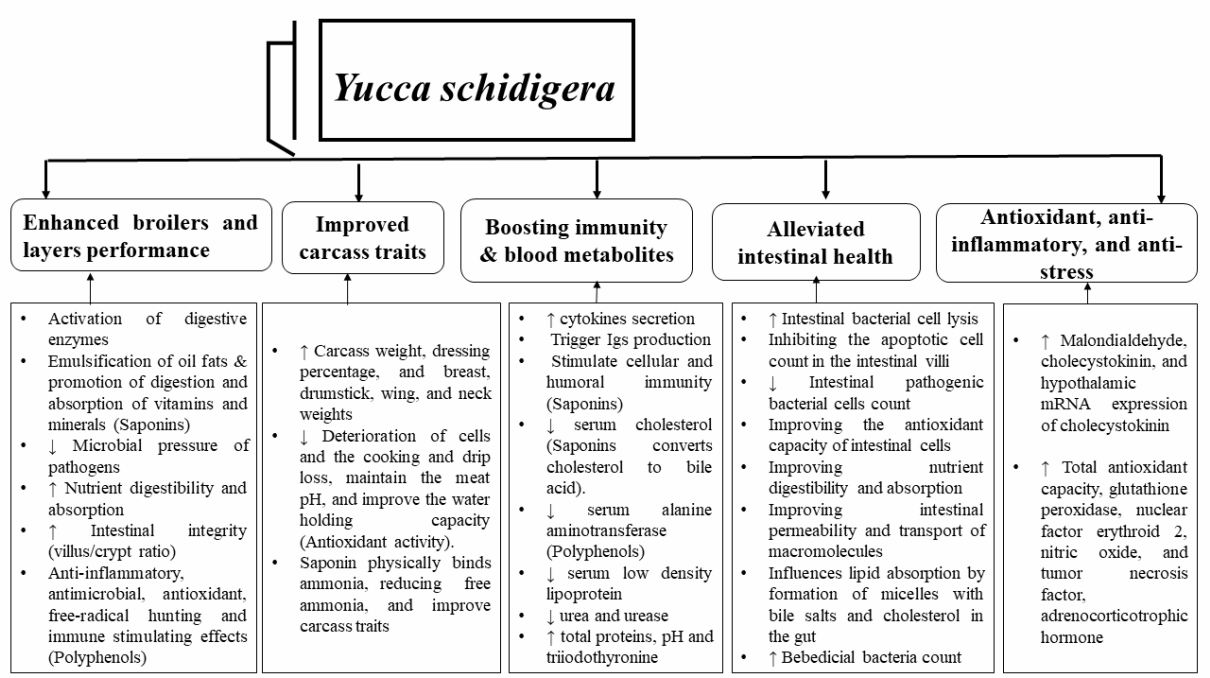

Figure 2 The modes of *Yucca schidigera* action in the birds body

Carcass traits

The effects of adding YS to the broiler diets (Sahoo *et al*. 2015; Munezero *et al*. 2023), drinking water (Benamirouche *et al*. 2020; Patoary *et al*. 2020; Rahman *et al*. 2023), or spraying of litter (Guclu, 2003) on the carcass characteristics have been investigated. Sahoo *et al*. (2015) showed that dietary inoculation of YS increased the breast and thigh weights. Also, Rahman *et al*. (2023) demonstrated that broiler chickens that received YS in the drinking water showed significantly higher dressing percentage and carcass weight than control birds. Recently, the drinking water treatment of *Eimeria*-infected broilers with YS and nano-emulsion resulted in better meat cuts than the infected untreated group (El-Sawah *et al*. 2025). The inclusion of YS extract and multi-carbohydrase in low crude protein diets of broilers induced positive influences on the carcass parameters (Munezero *et al*. 2023). Adding 100 mg/kg of YS has proven to improve the carcass yield, especially the carcass weight, dressing percentage, and breast, drumstick, wing, and neck weights (Alghirani *et al*. 2021). In addition, YS treatment in broilers induced significantly higher dressing percentage and carcass weight, as well as improvement in meat pH, drip loss %, and cooking loss % (Benamirouche *et al*. 2020). The steroidal saponins of YS extract could physically bind ammonia, reduce the level of free ammonia, and play a significant role in the improvement of economic traits on broiler chickens (Nazeer *et al*. 2002; Patoary *et al*. 2020).

Moreover, saponins in YS demonstrate antioxidant activity to protect against the deterioration of cells, maintain the pH value of meat, decrease the cooking and drip loss, and improve the water holding capacity (Zdanowska-Zdanowska-Sąsiadek *et al*. 2019; Alghirani *et al*. 2021). Saleh *et al*. (2018) showed that chickens supplemented with 0.5, 1, and 1.5 kg/ton herbal mixture, including Yucca, resulted in a significant reduction in meat malondialdehyde (MDA). On the other hand, Begum *et al*. (2015) demonstrated that Ross chickens fed 100 mg/kg caprylic acid and 100 mg/kg YE showed no significant increase in muscle lightness compared to the control group.

Intestinal health

The reduction in the crypt depth of the intestinal mucosa reflects epithelial cells' maturation and promotes intestinal secretion (Chen and Yu, 2020). The increase in villus height-to-crypt depth ratio improves the mucosa structure and villus absorptive area, leading to enhanced intestinal digestion and absorption of nutrients (Chen and Yu, 2020). Yucca showed an intestinal villus structure-improving effect (Dengsheng *et al*. 2017). The addition of SY could significantly increase the intestinal villus height and the villus height-to-crypt depth ratio, reduce the crypt depth, and improve barrier function in the proximal intestine of chickens and pigeons (Alfaro *et al*. 2007; Alagawany *et al*. 2016; Bafundo *et al*. 2021; Sun *et al*. 2023). In the study of Alghirani *et al*. (2021), the villi height of the duodenum,

jejunum, and ileum was increased linearly with increasing levels of YS addition in the broiler chickens' diets during the starter and finisher phases. An increase in the villus height of the duodenum, jejunum, and ileum was observed in layer hens supplemented with YS extracts (Gurbuz *et al*. 2011). The ileal villus length was significantly improved by YS and quillaja dietary supplementation (Bafundo *et al*. 2021). Recently, Dai *et al*. (2023) found that YS increased the villus height, improved the villus height-to-crypt depth ratio, and consequently enhanced the intestinal integrity of broilers. Administration of YS could increase the activities of trypsin and lipase in the jejunal digesta, enhance the jejunal villus height-to-crypt depth ratio, and alleviate the increasing jejunal crypt depth after infection of laying hens with *C. perfringens* and *Eimeria* spp. (Mao *et al*. 2023).
Bafundo *et al*. (2021) demonstrated that YS can reduce the intestinal harmful bacteria, regulate the intestinal flora, and improve the intestinal morphology. Furthermore, YS administration can mitigate the adverse effects of *C. perfringens* and *Eimeria* spp. challenge on histopathology and expression of tight-junction protein of jejunal mucosa, suggesting that YS enhanced gut barrier function (Mao *et al*. 2023).

The intestinal changes induced by YS are attributable to its influence on the intestinal microbial composition and mucosa, besides its ability to induce bacterial cell lysis. It has been reported that YS supplementation inhibited the apoptotic cell count in the jejunal villi of laying hens with *C. perfringens* and *Eimeria* spp. infection, thus reflecting the improved gut barrier function and protection of cell survival (Mao *et al*. 2023).

The dietary YS supplementation improved the antioxidant capacity of the proximal intestine of broilers (Alagawany *et al*. 2016). Similarly, Mao *et al*. (2023) reported that dietary addition of YS increased the total antioxidant capacity, decreased MDA level, and inhibited myeloperoxidase activity in the jejunal mucosa of *C. perfringens* and *Eimeria* spp. challenged layers. These results suggest that YS may relieve morphological damage and cell apoptosis caused by infection by improving the antioxidant capacity in the jejunal mucosa. Furthermore, YS can upregulate the expression of nuclear factor erythroid 2-related factor 2 and [NAD(P)H quinone dehydrogenase 1] in the jejunum of laying chickens infected by *C. perfringens* and *Eimeria* spp. (Mao *et al*. 2023).

Saponins, the major steroidal chemical elements, could ameliorate the intestinal absorption of nutrients (Sidhu and Oakenfull, 1986). Saponins of YS could improve intestinal health, decrease microbial pressure, and stabilize bowel health, but prevent intestinal disorder, which could lead to improved nutrient digestibility and absorption (Begum *et al*. 2015). Additionally, the intestinal presence of saponins has been shown to influence the permeability and transport of macromolecules through the intestinal cells. The presence of saponins in YS influences lipid absorption by the formation of micelles with bile salts and cholesterol in the gut (Cheeke, 2000).

Broiler chickens supplemented by YS significantly induced higher energy and protein levels, indicating better energy utilization and protein digestibility (Sahoo *et al*. 2015; Sahoo *et al*. 2016; Alghirani *et al*. 2021). It has been found that the extract of YS in Arbor Acres chickens can positively affect the energy metabolism through the modulating hormone secretions and depressing energy compounds in the organism (Sun *et al*. 2017). Moreover, chickens fed 200 and 300 mg/kg YS extract showed improvement in the antioxidant capacity of liver (Sun *et al*. 2017).
The short-chain fatty acids regulate the function of intestinal epithelial cells in order to improve the intestinal morphology and enhance the intestinal barrier and host metabolism (Martin-Gallausiaux *et al*. 2021). Increasing the intestinal content of short-chain fatty acids could affect ammonia emission by decreasing the fermentation intensity of animal protein in feed (Tsukahara and Ushida, 2000).

Gut flora has a significant role in influencing growth performance (Lan *et al*. 2020). Both the development of immunity and the preservation of the gut barrier are influenced by intestinal microbiota (Wang *et al*. 2023). Gut microflora interacts with the absorption of nutrients and the growth of the host's gastrointestinal tract, so it has a substantial effect on nutrition, health, and growth performance (Riyazi *et al*. 2015). YS can improve intestinal health by reducing the abundance of harmful intestinal flora. In YS-supplemented broiler chickens, the Lachnoclostridium concentration was significantly reduced, while Bacteroidota were significantly increased (Dai *et al*. 2023). The levels of tumor necrosis factor and interleukin (IL-) 6 are related to Lachnoclostridium concentration (Li *et al*. 2018). This indicated that YS can decrease the inflammation by reducing the Lachnoclostridium count in broilers. Moreover, a significant reduction of *Desulfovibrio piger* level was observed in YS-treated broiler chickens (Dai *et al*. 2023). Desulfovibrio spp. are sulfate-reducing bacteria that induce intestinal damage by decomposing sulfate and producing hydrogen sulfide. However, Ayoub *et al*. (2019) found that water treatment with YS resulted in a significant reduction in total aerobic colony count and an insignificant increase in lactic acid bacteria in broiler chickens. Similarly, Wang and Kim (2011) demonstrated that the addition of YS to the diets of laying hens did not affect Lactobacillus count.

According to its saponins content, Yucca exhibits ammonia-binding, urease activity-inhibiting, intestinal epithelial cell surface tension-reducing, antiprotozoal, antibacterial, antifungal, and antioxidant properties. Saponins show wa-

ter-and oil-soluble properties; therefore, they play an important role in the formation of micelles during fat absorption and also facilitate the passage of other nutrients through the intestinal epithelium (Franchis *et al*. 2002). In addition, this substance binds to the cell membranes of the intestinal pathogenic microorganisms, causing their death and exhibiting antibacterial effects (McAllister *et al*. 2001). Besides, saponins improve the nutrients' absorption via reducing the intestinal surface tension and triggering the intestinal villi development, thus having a positive influence on performance (Su *et al*. 2016). The study of Sun *et al*. (2023) showed that the oral supplementation of young pigeons with YS could improve the intestinal morphology by regulating the intestinal microbial community. The oral supplementation of YS increased the abundance of Patescibacteria and Desulfobacterota phyla as well as *Sulfurospirillum*, *Solobacterium*, *Desulfovibrio*, *Desulfobulbus*, *Lactococcus*, *Parabacteroides*, *Acidaminococcus*, and *Acetobacter* genera. *Desulfococcus* and *Desulfovibrio* are the main contents of sulfate-reducing bacteria, and *Desulfovibrio* have many enzymes acting together to resist oxidative stress (Dolla *et al*. 2006). In addition, the reduction of serum cholesterol levels following supplementation with YS may be controlled by the regulation of the intestinal Actinomyces genus abundance. Actinobacteria can induce secondary metabolites with structural diversity and are also the source of two-thirds of natural antibiotics and a series of anti-cancer, anti-parasitic, antifungal, and immunosuppressive drugs (Demain and Sanchez, 2009). The working principles of *Yucca* were explained in the study of Alghirani *et al*. (2021), who found that it decreased the microbial pressure by reducing the pathogenic bacteria (e.g., *Enterococcus faecalis*) and enhanced the growth of beneficial bacteria (e.g., Lactococcus, Streptococcus, and Parabacteroides).

These changes can alter beta diversity, enrich the microbial composition of gut, and decrease the risk of diarrhea by binding toxins, such as ammonia. Similarly, 5 to 10% of YS extract was sufficient to inhibit the growth of *Enterococcus faecalis* and *Enterococcus avium* in the manure of poultry (Matusiak *et al*. 2016). Hassan *et al*. (2010) demonstrated that quillaja and Yucca saponins may affect the activity of the intestinal *Salmonella enterica* ser. Typhimurium, *Escherichia coli* (*E. coli*), and *Staphylococcus aureus,* as well as other Gram-positive organisms. YS could be used for the treatment of salmonellosis by enhancing immune responses and activating antioxidative capacity (Abd Elmoteleb *et al*. 2024). Also, the study of Mert (2025) demonstrated a decrease in *E. coli* count, which suggests that the humate-Yucca combination may enhance economic efficiency by promoting intestinal health.

An increase in the digestion of essential minerals, improvement in the intestinal health, and reduction in the growth of pathogenic bacteria in broilers have been reported (Ebru *et al*. 2013; Sun *et al*. 2019). The presence of antimicrobial properties of YS is due to the high content of saponins (Matusiak *et al*. 2016). Steroidal saponins are poorly absorbed from the gastrointestinal tract, hence altering the microbial fermentation in the gut. Besides, Yucca supplementation could inhibit the proliferation and growth of pathogenic bacteria by reducing the intestinal ammonia levels (Alfaro *et al*. 2007).

The anticoccidial effect of YS in chickens has been reported in numerous studies (Trejo Castro, 2002; Oviedo *et al*. 2003; Alfaro *et al*. 2007; Galli *et al*. 2018; Oelschlager *et al*. 2019; Bafundo *et al*. 2020; Kozłowski *et al*. 2022; El-Sawah *et al*. 2025). It has been suggested that YS can be safely used as a coccidiostat for higher economical return and reducing the costs associated with coccidiosis problems in broiler farms (Kozłowski *et al*. 2022). Yucca-based saponins also displayed coccidiostat actions as measured by reduced oocyte production and protection against intestinal damage induced by the Eimeria in broilers (Galli *et al*. 2018). Mao *et al*. (2023) reported that dietary supplementation of YS extract improved digestion and absorption and promoted growth with a reduction of the negative effects of coccidiosis. A combination of quillaja and Yucca saponins exhibited anticoccidial effects in growing broilers (Bafundo *et al*. 2021; Saddoris-Clemons *et al*. 2024). The treatment of Eimeria-infected broiler chickens with a mixture of YS and *Quillaja saponaria* produced positive influences on growth performance, intestinal health, and immunity during both the peak and recovery phases following a coccidia infection (Saddoris-Clemons *et al*. 2024). A combination of coccidiostats (monensin and salinomycin) plus YS increased the intestinal crypt depth and reduced the villus-to-crypt ratio in broiler chickens (Alfaro *et al*. 2007). Trejo Castro (2002) demonstrated that Eimeria oocysts count and the gut lesion scores were reduced in chickens treated with YS compared to narasin, salinomycin, monensin, and nicarbazin ionophores. Moreover, YS in combination with monensin and salinomycin (anticoccidial), Stafac (antiinfective), and bacitracin methylene disalicylate was very effective in improving the growth and FCR and reducing oocyst index in chickens infected with Eimeria spp. (Oviedo *et al*. 2003). Similar results were obtained by Alfaro *et al*. (2007), who demonstrated a potent synergistic coccidiostat influence of both anti-coccidia vaccine and YS when compared to monensin and salinomycin. Recently, feed treatment of broiler chickens with YS resulted in improving the FCR and average daily gain and diminishing the oocyst per gram counts compared to the anticoccidial and challenged groups (Kozłowski *et al*. 2022). So, the anticoccidial effect of YS may be attributed to reducing oocyst count and enhancing the body performance of the

treated broilers (Kozłowski *et al*. 2022). The extract of YS is rich in steroidal saponins that interact with cholesterol in the protozoan cell membrane during the different developmental stages and consequently prevent the parasites' development and destroy them by lysis (Wang *et al*. 1998; Cheeke *et al*. 2006; Bafundo *et al*. 2020; Kozlowski *et al*. 2022).

The previous findings vary from those of Oelschlager *et al*. (2019), who demonstrated a reduction in interleukin (IL-1β) with no impact on interferon-γ or IL-12β in the duodenum at 7 days after Eimeria infection in chickens fed 250 to 500 mg/kg of a Yucca-derived saponin. This discrepancy may probably be explained by the differences in sources, quality, and composition of the tested YS and consequently the amount of steroidal saponins that are responsible for the antiprotozoal effect and the effect on the digestion process.

Immunity

YS has stimulating, inhibiting, or regulating immune effects (Dai *et al*. 2023) as its contents of steroidal saponin extracts can enhance cytokine secretion, trigger immunoglobulin (Ig) production, and stimulate both cellular and humoral immune responses (Song and Hu, 2009). Su *et al*. (2016) demonstrated that the inclusion of YS powder in broiler ration (100 or 200 mg/kg) stimulated cellular and humoral immune responses. Moreover, dietary YS can linearly increase the IgG production in the serum of laying hens (Alagawany *et al*. 2016) and broilers (Ayoub *et al*. 2019). In the study of Dai *et al*. (2023), high levels of IgA and IgY were detected in the serum of YS-treated broiler chickens. A high concentration of IgM was observed in 35-day-old broiler chickens treated with YS and inoculated with sheep red blood cells (Amirbeik *et al*. 2018). Moreover, the total protein and IgM contents in the serum were significantly higher in young pigeons treated with a dietary YS than in birds in the control non-treated group (Sun *et al*. 2023). The study of Mert (2025) indicated that humate and Yucca supplementation are efficient in enhancing the production of IgA and IgM levels both alone and in combination. Also, Bafundo *et al*. (2021) found that the combination of Yucca and Quillaja augmented intestinal health by increasing IgA and IgM levels. Increasing the intestinal lactic acid bacterial count can improve nutrient absorption and immunological response by establishing the intestinal barrier function (Mert, 2025). Alghirani *et al*. (2021) reported the effect of *Yucca* on the host's immunity as follows: it promotes the humoral immunity by elevating the serum IgM and total protein levels. Through polyphenols, Yucca exhibits anti-inflammatory effects, improves antioxidant status, and reduces liver enzymes (e.g., alanine aminotransferase). By strengthening gut morphology (increasing villus height and reducing crypt depth), Yucca indirectly augments the immune barrier. YS can also boost the immune response by elevating lysozyme levels and hemagglutination inhibition antibody titer in Salmonella-infected and YS-treated broilers (Abd Elmoteleb *et al*. 2024). On the other hand, the study of Sun *et al*. (2023) demonstrated that the weight of immune organs, including the thymus glands, bursa of Fabricius, and spleen, was not affected following supplementation of young pigeons with a dietary YS.

Blood metabolites

The liver enzymes, such as serum alanine aminotransferase level, in YS-supplemented young pigeons were significantly lower than those in the control non-treated group (Sun *et al*. 2023). The low level of liver enzymes may be due to the richness of YS in phenolic components (Piacente *et al*. 2004; Bidinotto *et al*. 2011). The serum low-density lipoprotein level was the lowest in broiler chickens treated with 0.015% YS powder when compared with other groups (Amirbeik *et al*. 2018). The concentration of serum total cholesterol was significantly decreased in YS-treated layers and broilers when compared with control group (Kaya *et al*. 2003; Bafundo *et al*. 2021; Sun *et al*. 2023). Saponins with cholesterol form water-insoluble complexes which accelerate the liver conversion of cholesterol to bile acid, and consequently, the level of cholesterol in the serum was decreased (Sidhu and Oakenfull, 1986). The dietary supplementation of YS extract reduced urea, urease, and creatinine concentrations, maintained albumin and globulin at normal levels, and enhanced total proteins and triiodothyronine (T3) concentrations in the blood of broiler chickens (Baker, 1997; Abd Elmoteleb *et al*. 2024). In the study of El-Sawah *et al*. (2025), the results indicated that both forms of YS and its nano-emulsion were safe for the liver and kidney in terms of normal liver and kidney function tests levels. A parallel finding of Abd Elmoteleb *et al*. (2024) revealed that YS treatment may boost liver antioxidant activity and modify renal function owing to its antioxidant-active components, which include steroidal saponins, flavonoids, and polyphenols. Moreover, Yucca can reduce the blood urea levels by inhibiting its formation in the liver and increasing urea elimination (Abd Elmoteleb *et al*. 2024). In addition, the levels of T3 and thyroxine (T4) hormones were significantly increased in the humate and YS-supplemented broilers compared to the control group (Mert, 2025).

These findings suggest that humate and Yucca supplementation support metabolic processes and increase thyroid hormone production. Similar results were reported by Obianwuna *et al*. (2024), who found that *Yucca*-containing mixtures increased T3 and T4 levels by 10% and that this effect was associated with the relationship between gut health and metabolic efficiency.

Antioxidant properties

Previous studies showed the antioxidant properties of YS in poultry (Alagawany *et al*. 2016; Farag *et al*. 2018; Awad *et al*. 2021). The serum contents of MDA were decreased, while the total antioxidant capacity and glutathione peroxidase activity were increased in broilers supplemented with dietary YS (Dai *et al*. 2023). The reduction of MDA level may be due to the capability of YS to eliminate secondary reactive radicals or inhibit superoxide and hydrogen peroxide production (Enginar *et al*. 2006). Nearly similar results were obtained by Luo *et al*. (2022), who demonstrated a reduction in the plasma lipid oxidation product MDA, cholecystokinin, and hypothalamic mRNA expression of cholecystokinin, without an effect on the activities of superoxide oxidase and glutathione peroxidase in YS-treated broilers under high ambient temperature. Moreover, dietary addition of YS upregulated the expression of nuclear factor erythroid 2-related factor 2 and [NAD(P)H quinone dehydrogenase 1] in the jejunal mucosa of laying hens infected by *C. perfringens* and *Eimeria* spp. (Mao *et al*. 2023). The nuclear factor erythroid 2-related factor 2 signaling pathway plays a key role in regulating antioxidant enzyme functions; therefore, a lack of this factor induces a dysfunction of the antioxidant system (Cheung *et al*. 2014).

Supplementation with YS reduced the lipid-oxidative indicators, indicating its antioxidant capacity (Luo *et al*. 2022). It acts by enhancing the nuclear factor erythroid 2-related factor 2 signaling pathway (Dai *et al*. 2023), which is an antioxidant pathway (Wang *et al*. 2020), and increases glutathione peroxidase production (Gao *et al*. 2016). Dietary saponins from YS extracts at a level 100 mg/kg improved the antioxidant capacity in the small intestine and increased the gene expression of superoxide dismutase, glutathione peroxidase, and catalase (Sun *et al*. 2019). The protopanaxadiol saponin fraction may reduce the release of some inflammatory cytokines, including nitric oxide and tumor necrosis factor, blocking p38, c-Jun N-terminal kinase, and other proteins through downregulating mRNA gene expression (Yang *et al*. 2015).

Anti-inflammatory properties

The whole-plant Yucca powder has shown powerful anti-inflammatory activity, mediated via inhibition of nuclear factor kappa B (NF-κB) activation (Cheeke *et al*. 2006). The dietary YS increased the total antioxidant capacity, decreased MDA level, and inhibited myeloperoxidase activity in the jejunal mucosa of *C. perfringens* and *Eimeria* spp. challenged layers (Mao *et al*. 2023). The myeloperoxidase is mostly expressed in inflammatory cells (particularly neutrophils) and is known to be significant in tissue damage and inflammation in different inflammatory disease conditions (Aratani, 2018). Yucca saponins can decrease cytokine concentrations associated with inflammatory responses (Oelschlager *et al*. 2019; Abd Elmoteleb *et al*. 2024). The steroid saponin molecules in YS have a similar structure to glucocorticoid; thus, these molecules exert a glucocorticoid-like effect through glucocorticoid receptors, e.g., antioxidant (Su *et al*. 2016; Farag *et al*. 2018) and anti-inflammatory properties (Cheeke *et al*. 2006; Dai *et al*. 2023). Additionally, polyphenols in Yucca can reduce the reactive oxygen species and interrupt the inflammatory response by scavenging free radicals in cells (Dai *et al*. 2023). The activated macrophages generate IL-6, a pro-inflammatory cytokine that initiates and worsens the inflammation course (Abdel-Tawwab *et al*. 2021). Yucca bark and whole Yucca plant powder contain resveratrol, which is known for its anti-inflammatory activity (Bhat and Pezzuto, 2002). The IL-6 mRNA gene expression is related to high resveratrol (polyphenol) levels in Yucca. Resveratrol may block the NF-κB pathway, resulting in a decrease in IL-6 transcription (Attallah *et al*. 2022).

The reduced plasma level of fluorescein isothiocyanate dextran in Eimeria-challenged-YS treated chickens pointed to the protective effect of the plant on the intestinal barrier and a reduction in leakiness that is often a result of inflammation-induced damage (Saddoris-Clemons *et al*. 2024). This suggested that feeding YS may help to diminish the acute inflammatory response, potentially limiting the tissue damage associated with excessive inflammation due to coccidiosis (Saddoris-Clemons *et al*. 2024).

Anti-stress properties

YS could alleviate the heat stress and improve the general health conditions of broiler chickens (Rezaei *et al*. 2017; Luo *et al*. 2022). Supplementation with YS alleviated the stress of high temperature and accordingly reduced the rectal and leg skin temperature (Luo *et al*. 2022). Yucca may increase the antioxidant status and alleviate the heat stress reaction in developing broilers via controlling gene expression that senses body temperature in the hypothalamus (Luo *et al*. 2022). Saponin component of YS has an antidepressant effect in animals (Abbas *et al*. 2014). For instance, intraperitoneal injection of mice with ginseng saponin (5 or 20 mg/kg BW) reduced the adrenocorticotropic hormone, which induces stress (Kim *et al*. 2003). In the study of Luo *et al*. (2022), the high temperature reduced the hypothalamic mRNA expression of transient receptor potential melastatin type 8, while treatment with YS increased the mRNA expression of both heat (transient receptor potential vanilloid receptors 1 and 4) and cool (transient receptor potential melastatin type 8) sensing receptors. These results indicate the increased YS thermoregulation capacity under heat stress, thereby attenuating the increased body temperature induced by high temperature. Moreover,

YS prevented the reduced FI of broilers exposed to heat stress conditions (Luo *et al*. 2022), which may be due to the antioxidant capacity of YS, especially in the hypothalamus (Alagawany *et al*. 2018; Luo *et al*. 2018).

CONCLUSION

The findings of this article highlight the potential of plant-based feed additives as sustainable alternatives to conventional growth promoters in poultry production systems. YS is a very suitable feed additive that has the ability to ameliorate the general health of poultry. It has advantages for improving the performance of broilers and layers, carcass traits, intestinal health, immunity, and some blood parameters and reducing serum oxidant, inflammatory, and stress factors in different poultry species. Therefore, YS could be safely used in poultry production systems for higher economical return without any adversity. A continued investigation into the use of natural feed additives for poultry will help in the development of effective and sustainable strategies for optimizing the health and production.

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