

| ORIGINAL SCIENTIFIC ARTICLE |

Effect of condensed (quebracho) and hydrolysable (sweet chestnut) tannins on growth performance and contact dermatitis in broilers

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moisture, and the severity of footpad dermatitis and hock burn dermatitis were recorded. The group supplemented with hydrolysable tannins had a significantly higher final body weight and average daily gain, compared to the control. Both tannin-supplemented groups showed significantly lower litter moisture and a reduced severity of contact dermatitis lesions throughout the study. In conclusion, this study suggests that tannins, particularly hydrolysable tannins, may improve broiler growth and reduce the severity of contact dermatitis, highlighting their potential as functional feed additives. However, further research is required to determine optimal inclusion levels and elucidate their mechanisms of action.

Key words: *condensed tannins; hydrolysable tannins; growth performance; contact dermatitis; broilers.*

Abstract

The aim of this study was to evaluate the effects of dietary supplementation with condensed (quebracho) and hydrolysable (sweet chestnut) tannins on growth performance and the severity of contact dermatitis in broiler chickens. A total of 150 Ross 308 broilers were divided into three groups: a control group (no tannins), a group receiving hydrolysable tannins, and a group receiving condensed tannins, each at a dose of 0.75 g/kg of feed over a 42-day fattening period under commercial conditions. Body weight gain, feed conversion ratio, litter

Introduction

Modern intensive poultry farming plays a crucial role in ensuring global food security, though it poses constant challenges for animal welfare. A major welfare concern in broiler production is contact dermatitis (CD), particularly in the form of

foot pad dermatitis (FPD) and hock burn dermatitis (HBD), which result from a combination of rapid growth, restricted mobility and sub-optimal litter quality (Bessei, 2006; De Jong et al., 2014). These lesions not only affect animal welfare, but also lead to economic losses (Freeman et al., 2020).

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Table 1. Experimental treatments

Group	Treatment	Dosage (g/kg)		
		Starter	Grower	Finisher
CON	-	-	-	-
FAR	Farmatan (Farmatan, Sevnica, Slovenia)	0.75	0.75	0.75
QUE	Quebracho	0.75	0.75	0.75

While environmental factors, particularly litter moisture, have been shown to contribute significantly to the development of CD (Taira et al., 2014), the role of diet in its possible prevention is still unexplored. Moreover, since the 2006 ban on antibiotic growth promoters in the European Union, attention on nutritional strategies that support poultry performance and welfare has increased significantly (Yilmaz, 2024).

Among the proposed alternatives, tannins, polyphenolic compounds derived from plants, have gained interest due to their antimicrobial, anti-inflammatory and antioxidant properties (Smeriglio et al., 2016; Huang et al., 2018). They are broadly classified into two types: condensed tannins (e.g., from quebracho) and hydrolysable tannins (e.g., from sweet chestnut), and differ in their molecular complexity and mode of action (Hassanpour et al., 2011). However, the results of studies on their use in poultry production are limited. Some studies report performance and health benefits (Mašek et al., 2014; Liu et al., 2023), while others emphasise their potentially detrimental nutritional effects (Thakur et al., 2019; Hidayat et al., 2021). In addition, the biological activity of tannins varies greatly depending on their chemical structure and dosage (Frutos et al., 2004; Aboagye and Beauchemin, 2019).

The aim of this study was to evaluate the effects of dietary supplementation with condensed and hydrolysable tannins on growth performance and the severity of contact dermatitis in broilers.

Material and Methods

This study was approved by the Veterinary Medicine Ethics Committee, Faculty of Veterinary Medicine, University of Zagreb, Croatia. The experiment was conducted under commercial conditions at a family farm in Croatia, using 150 Ross 308 hybrid broilers over a six-week fattening period.

Broilers were randomly divided into the following groups: control (CON), farmatan (FAR), and quebracho (QUE), each comprising five replicates with ten broilers per replicate. Table 1 presents details of tannin supplementation. A three-phase feeding program was implemented: starter (days 1–21), grower (days 21–35), and finisher (days 35–

42). Feed and water were provided *ad libitum*, and all diets were offered in mash form. The ingredient composition and chemical analysis of the diets are presented in Table 2. Broilers were housed on wood shavings.

Measurements

Growth performance

Body weight (BW) and feed intake of all broilers were recorded weekly. Based on these data, body weight gain, feed consumption, and feed conversion ratio (FCR, g feed/g gain) were calculated per replicate for each feeding phase.

Litter moisture

Litter samples were collected weekly from three locations within each treatment group. Samples were weighed fresh and after drying at 105°C until constant weight. Litter moisture was calculated as follows:

$$\% \text{ moisture content of litter} = \frac{(\text{weight of wet litter} - \text{weight of dry litter}) \times 100}{\text{weight of wet litter}}$$

Severity of contact dermatitis

The severity of FPD and HBD were evaluated weekly using the Welfare Quality® assessment protocol (Welfare Quality® Consortium, 2009). When lesions of varying severity were present, more severe changes were recorded. Figures 1 and 2 illustrate the scoring scales for FPD and HBD used in the assessment.

Statistical analyses

All statistical analyses were performed using GraphPad Prism version 8.0 (GraphPad Software, San Diego, CA, USA). The Shapiro-Wilk test was applied to assess the normality of data distribution. Results are presented as mean ± standard deviation (SD). Differences between group means were evaluated using one-way analysis of variance (ANOVA), followed by Tukey's post hoc test for multiple comparisons. Statistical significance was set at $P < 0.05$.

Table 2. Ingredients and nutrient content of the diets fed during the study

Ingredients and nutrient content (g kg ⁻¹)	Starter (1 st to 21 st day)	Grower (22 nd to 35 th day)	Finisher (35 th to 42 nd day)
Ingredient			
Corn	455	600	688
Wheat bran	125	30	–
Soybean meal	215	125	180
Alfalfa meal	–	–	30
Yeast	50	50	–
Sunflower meal	100	145	45
Vegetable oil	5.0	–	7.0
Mineral and vitamin mixture*	50	50	50
Nutrient content (g kg⁻¹)			
Crude protein	221.5	209.2	195.2
Crude fat	69.0	70.5	71.3
Crude fibre	33.1	32.1	32.0
Calcium	10.3	10.1	10.6
Phosphorus	6.6	6.3	6.2
Lysine	14.2	12.7	11.5
Methionine	6.0	5.8	5.9
Metabolisable energy (MJ)	12.4	13.0	13.3

*Comprising per kg of mineral and vitamin mixture: Ca, 180 g; P, 50 g; Na, 23 g; methionine, 50,000 mg; lysine, 24,000 mg; retinol acetate, 90 mg; cholecalciferol, 1 mg; DL- α -tocopherol acetate, 600 mg; menadione, 40 mg; thiamine hydrochloride, 20 mg; riboflavin sodium phosphate, 120 mg; pyridoxine, 40 mg; cyanocobalamin, 300 μ g; vitamin C, 300 mg; niacin, 800 mg; calcium pantothenate, 240 mg; folic acid, 10 mg; biotin, 2 mg; choline chloride, 10 g; Fe, 1200 mg; I, 1200 mg; Cu, 100 mg; Mn, 1600 mg; Co, 3 mg; Zn, 1000 mg; Se, 3 mg; BHT antioxidant, 3000 mg.

Results

Growth performance

The results of growth performance are presented in Figure 3. On day 42, the body weight of broilers in the FAR group was significantly higher ($P < 0.05$) compared to the control (CON) group. No significant differences were observed between the CON and QUE groups, or between the FAR and QUE groups.

No statistically significant differences were observed in feed conversion ratios among the CON, FAR, and QUE groups over the 42-day experimental period (Figure 3).

During the starter phase (days 1–21) and grower and finisher phase (days 21–42), the FAR group had a significantly higher ($P < 0.05$) average daily weight gain compared to the CON group. No significant differences were observed between the CON and QUE groups, or between the FAR and QUE groups.

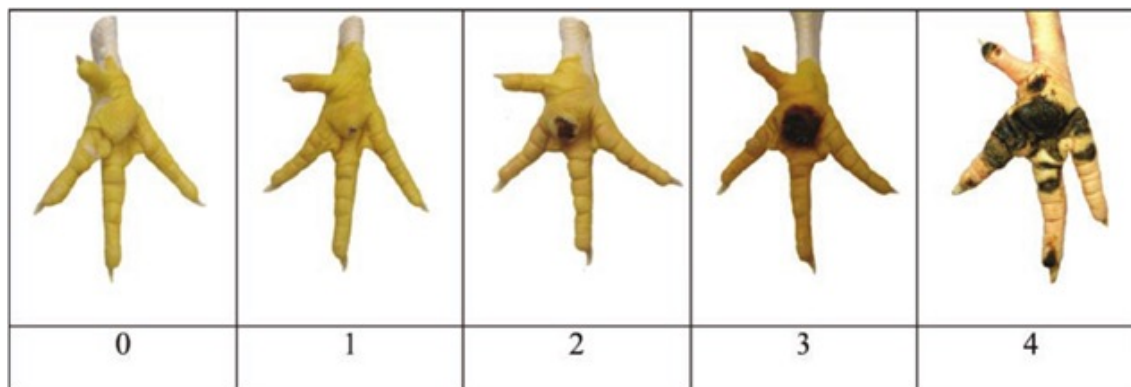
Litter moisture

Litter moisture content averaged 45.6% in the CON group, 40.1% in FAR, and 41.1% in QUE. Both the FAR and QUE groups had significantly lower values ($P < 0.05$) compared to the CON. Additionally, the FAR group showed significantly lower ($P < 0.05$) moisture values than the QUE group.

Occurrence of contact dermatitis

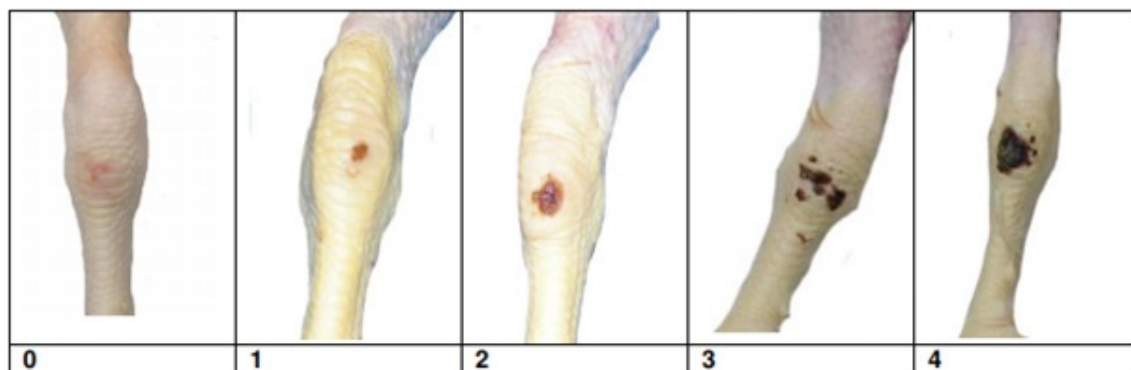
The severity of FPD was significantly reduced ($P < 0.05$) in both the FAR and QUE groups compared to the CON group throughout the study. In the early phases (days 14, 21, and 28), the QUE group also showed significantly lower FPD scores than the FAR group. Regarding HBD, both tannin-supplemented groups demonstrated significantly lower lesion severity than the CON group from day 28 onward, (Table 3).

Figure 1. Scale for assessing the occurrence of foot pad dermatitis of broilers



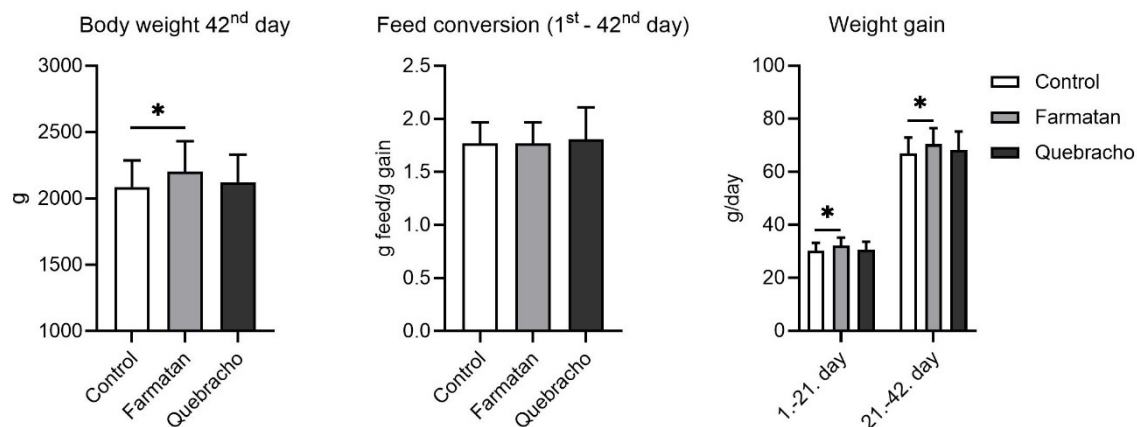
(Source: Welfare Quality® Consortium, 2009)

Figure 2. Scale for assessing the occurrence of hock burn dermatitis of broilers



(Source: Welfare Quality® Consortium, 2009)

Figure 3. Growth performance of experimental animals



Discussion

Tannins have traditionally been considered antinutritive factors in the diet of monogastric animals, mainly due to their potential to reduce nutrient availability and impair growth performance (Thakur et al., 2019). Recent research has increasingly emphasised the potential of tannins as functional feed additives in poultry nutrition. When used in appropriate concentrations, they can have

positive effects on animal health, performance and carcass quality due to their antimicrobial, anti-inflammatory and antioxidant properties (Kubena et al, 2001; Mašek et al, 2014; Starčević et al, 2015; Cengiz et al, 2017). However, most available studies have focused on individual tannin type, while comparative assessments between condensed and hydrolysable tannins remain limited, especially regarding potential synergistic effects. This

Table 3. Occurrence of foot pad dermatitis (FPD) and hock burn dermatitis (HBD) in animals in the three experimental groups

Day	CON	FAR	QUE
FPD			
14	0.53 ± 0.25 ^a	0.27 ± 0.24 ^b	0.05 ± 0.00 ^c
21	1.67 ± 0.48 ^a	1.23 ± 0.43 ^b	0.43 ± 0.20 ^c
28	2.40 ± 0.50 ^a	2.00 ± 0.33 ^b	1.43 ± 0.51 ^c
35	2.77 ± 0.43 ^a	2.23 ± 0.43 ^b	2.30 ± 0.47 ^b
42	3.00 ± 0.18 ^a	2.53 ± 0.50 ^b	2.60 ± 0.50 ^b
HBD			
21	1.00 ± 0.18 ^a	0.77 ± 0.43 ^b	0.83 ± 0.37 ^a
28	2.00 ± 0.24 ^a	1.73 ± 0.44 ^b	1.77 ± 0.43 ^b
35	3.00 ± 0.33 ^a	2.43 ± 0.50 ^b	2.40 ± 0.49 ^b
42	3.60 ± 0.49 ^a	3.00 ± 0.26 ^b	2.97 ± 0.31 ^b

CON – control; FAR – hydrolysable tannin; QUE - quebracho

^{a,b,c} Values within rows with different superscripts are significantly different ($P < 0.05$) by the Tukey–Kramer procedure.

study provides one of the first direct comparisons between condensed and hydrolysable tannins in broiler diets, offering a new approach to addressing the challenges of modern broiler production.

Some studies have shown that tannins can have a positive effect on growth performance (Mašek et al., 2014; Liu et al., 2023; Maysonave et al., 2024). However, tannins can have a negative effect on average daily gain and feed intake in broilers (Hidayat et al., 2021) and have been associated with lower protein digestibility (Redondo et al., 2014). At the end of this study, the broilers fed hydrolysable tannins had a significantly higher final body and weight gain compared to the control group. These results support the hypothesis that the chemical structure and botanical origin of the tannins influence their effect (Chung et al., 1998; Frutos et al., 2004).

Tannins are also seen as a potential strategy to mitigate problems in poultry production, including adverse effects on broiler welfare (Choi and Kim, 2020). Contact dermatitis poses a problem for broiler welfare as it causes pain and restricts natural behaviours (Freeman et al., 2020). As these conditions are due to a combination of environmental and nutritional factors, dietary supplements with multiple biological effects, such as tannins, can play a role in prevention. Tannins have been shown to improve faecal consistency and increase dry matter content, leading to improved

litter quality and consequently a lower incidence of FPD (Choi et al., 2022). In this study, both groups receiving tannins had significantly lower litter moisture, with the lowest values measured in the FAR group.

It has been demonstrated that the antimicrobial, antioxidant and anti-inflammatory properties of tannins may contribute to their potential to alleviate the effects of FPD, as oxidative stress and inflammation are known to contribute to the development and progression of the condition (Mayne et al., 2007). Cengiz et al. (2017) reported that dietary supplementation with 2000 mg/kg tannic acid reduced both the incidence and severity of FPD lesions. Similarly, Rezar et al. (2014) observed that chestnut extract, which is rich in hydrolysable tannins, increased faecal dry matter content, thus improving litter conditions. In this study, groups receiving tannins had significantly reduced FPD severity compared to the control, with condensed tannins performing better in the early phase. From day 28 onward, both groups also had significantly less severe HBD lesions. Afterwards, there was no difference between FAR and QUE.

Although the exact mechanisms of action are still unclear, the results of this study suggest that tannin supplementation, especially with hydrolysable tannins, can positively influence the growth performance and skin health of broilers.

Conclusion

This study suggests that tannins, especially hydrolysable tannins, can increase growth performance and reduce the severity of contact dermatitis

in broilers, supporting their potential as functional feed additives in poultry production. However, further research is needed to identify optimal dosing strategies and to better understand the underlying mechanisms of action of the different types of tannins.

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> Učinak kondenziranih (quebracho) i hidrolizirajućih (slatki kesten) tanina na proizvodne pokazatelje i kontaktni dermatitis u tovnih pilića

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Cilj je ovog istraživanja bio ispitati učinak dodatka kondenziranih (quebracho) i hidrolizirajućih (slatki kesten) tanina u obroku na proizvodne pokazatelje i izraženost kontaktnih dermatitisa u tovnih pilića. Ukupno 150 tovnih pilića hibrida Ross 308 bilo je raspoređeno u tri skupine: kontrolnu skupinu (bez dodatka tanina), skupinu koja je u obroku dobivala hidrolizirajuće tanine te skupinu kojoj su dodani kondenzirani tanini. Obje skupine s taninima primale su dodatak u dozi od 0,75 g/kg stočne hrane tijekom 42-dnevnog tovnog razdoblja provedenog u komercijalnim uvjetima. Tijekom pokusa pratili su se prirast, konverzija hrane, vlaga stelje te izraženost kontaktnog dermatitisa na jastučićima nogu i tarzalnom zglobu. Skupina koja je primala hidrolizirajuće tanine imala je značajno veću završnu tjelesnu masu i prosječni dnevni prirast, osobito tijekom početne

faze tova, u odnosu na kontrolnu skupinu. Obje skupine s dodatkom tanina imale su značajno nižu vlagu stelje te manju izraženost kontaktnih dermatitisa tijekom cijelog pokusa, pri čemu je učinak bio izraženiji u skupini s hidrolizirajućim taninima. Zaključno, rezultati ukazuju na to da tanini, osobito hidrolizirajući podrijetlom iz slatkog kestena, mogu povoljno utjecati na rast tovnih pilića i smanjiti izraženost kontaktnih dermatitisa, čime se potvrđuje njihov potencijal kao funkcionalnih dodataka u hranidbi peradi. Ipak, potrebna su daljnja istraživanja radi optimizacije doziranja i boljeg razumijevanja mehanizama njihova djelovanja.

Ključne riječi: kondenzirani tanini, hidrolizirajući tanini, proizvodni pokazatelji, kontaktni dermatitis, tovnici pilići.