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EFFECTS OF DIFFERENT DETOXIFICATION METHODS ON GROWTH PERFORMANCE, CARCASS TRAITS, AND ORGAN WEIGHTS IN BROILERS FED *PONGAMIA PINNATA* SEEDS

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ABSTRACT
This study evaluated the effects of various detoxification methods on *Pongamia pinnata* seeds and their impact on growth performance, carcass traits, organ weights, and mortality in broiler chickens. A total of 400 day-old broiler chicks were randomly assigned to ten groups (four replicates of ten birds each). Treatments included a control diet and diets containing 3% *P. pinnata* seeds detoxified using Na_2CO_3, hydrochloric acid, glacial acetic acid, methanol soaking, polyethylene glycol (PEG), enzyme, hot air oven, water washing, or untreated seeds. Results showed that the control group had the highest feed intake (3462.3 g/bird), followed by Na_2CO_3 (3377.8 g/bird) and hydrochloric acid (3321.5 g/bird) treatments. Similarly, maximum live body weight was in the control group (2116.3 g/bird), followed by Na_2CO_3 (2005 g/bird). The best feed conversion ratio (FCR) was observed in the control group (1.74), followed by Na_2CO_3 (1.83). All detoxification methods improved performance compared to untreated seeds. Liver weight was significantly affected ($p < 0.05$), while spleen, heart, and gizzard weights were not. Mortality was 5% in control, Na_2CO_3, PEG, and enzyme groups, and 7.5% in others. In conclusion, Na_2CO_3 detoxification of *P. pinnata* seeds significantly improved broiler growth performance and carcass traits, making it a promising alternative feed ingredient.

KEYWORDS: Growth performance; FCR; soaking methods; broiler; *Pongamia pinnata*

INTRODUCTION
Broiler production is a major component of the global livestock sector, providing an efficient source of high-quality animal protein. Broiler growth, feed efficiency, and productivity depend strongly on dietary quality and nutritional balance (Zampiga et al., 2021). The increasing demand for poultry meat has intensified the search for sustainable and cost-effective alternative feed ingredients, particularly where conventional protein sources such as soybean meal are costly or limited. *Pongamia pinnata* (Karanja), an oilseed-producing leguminous tree native to South and Southeast Asia, is a promising alternative due to its protein- and lipid-rich seeds. However, raw *P. pinnata* seeds contain anti-nutritional and toxic compounds, particularly karanjin and pongamol, which may impair nutrient utilization, hepatic function, and animal performance if not adequately detoxified (Panwar et al., 2026).Various detoxification techniques such as water soaking, solvent extraction, heat treatment, and fermentation have been shown to effectively reduce the toxicity of these compounds, thereby improving the safety and nutritional value of the seed meal (Zhang et al., 2026).
Broiler growth performance is strongly influenced by the nutritional quality and safety of feed. Increasing attention has been directed toward unconventional feed ingredients, including detoxified *Pongamia pinnata* seed meal, as sustainable alternatives to conventional protein sources (Ahmed et al.,2025). *P. pinnata* is a protein- and oil-rich leguminous tree widely distributed in tropical regions; however, its application in poultry diets is constrained by anti-nutritional and toxic compounds, particularly karanjin and pongamol (Panwar et al., 2026). Importantly, studies indicate that appropriately detoxified *P. pinnata* seed meal can support comparable or improved broiler performance, including body weight gain, feed intake, and feed conversion efficiency, compared with conventional diets (Khan et al., 2024). Incorporation of detoxified *Pongamia pinnata* seed meal into broiler diets offers a cost-effective protein source while promoting agro-industrial waste valorization and environmental sustainability. When appropriately detoxified, *P. pinnata* seed meal has shown potential to support broiler growth and feed efficiency. Experimental studies have reported comparable or improved body weight gain, feed intake, and feed conversion ratio (FCR) when detoxified *Pongamia* seed meal is included at moderate dietary levels (Raj, et al., 2016).The high protein content and favorable amino acid profile support muscle development, while the residual bioactive compounds may confer additional benefits such as antimicrobial and antioxidant effects, which can improve gut health and immune function (Leite et al., 2026; Keohavong et al., 2025).
he exploration of *Pongamia pinnata* seeds as a feed ingredient holds significant potential for enhancing broiler production while promoting sustainability in the poultry industry. This study aims to assess the influence of various

methods of detoxification of *Pongamia pinnata* seed inclusion on the growth traits of broiler chickens, focusing on its impact on feed efficiency and overall performance.

MATERIALS AND METHODS

Experimental Design

Based on the results of a preliminary trial, a subsequent experiment was conducted using 3% *Pongamia pinnata* seeds in broiler diets. A total of 400 day-old broiler chicks were procured from a commercial hatchery and transported to the Poultry Experimental Station, Department of Poultry Husbandry, Faculty of Animal Husbandry and Veterinary Sciences, Sindh Agriculture University, Tandojam. The birds were randomly assigned to ten treatment groups according to the design outlined in Table 1.

Table 1. Experimental grouping of broilers.

Group	Treatment	No. of Birds	No. of Replicates	No. of Birds/Replicate
T0	Control	40	4	10
T1	Na_2CO_3	40	4	10
T2	Hydrochloric acid	40	4	10
T3	Glacial acetic acid	40	4	10
T4	Methanol soaking	40	4	10
T5	Polyethylene glycol	40	4	10
T6	Enzyme	40	4	10
T7	Hot air oven	40	4	10
T8	Water washing	40	4	10
T9	Pongamia (untreated)	40	4	10

Feed Formulation

The experimental diets were formulated as per the ingredient composition presented in Table 2.

Table 2. Feed formulation (g/kg).

Ingredients	Pre-Starter (g/kg)	Finisher (g/kg)
Maize	560.0	550.0
Pongamia pinnata	50.0	50.0
Canola meal	100.0	100.0
Soybean meal	200.0	207.0
Fish meal	60.0	62.0
Limestone	8.0	8.0
Dicalcium phosphate (DCP)	7.0	7.0
Lysine	6.5	7.0
Methionine	2.5	3.0
Vitamin–mineral premix	6.0	6.0
Calculated Chemical Composition		
Crude protein (%)	22.0 ± 0.2	-
Metabolizable energy (Kcal/kg)	3350 ± 70	-

Housing and Management

Floor space was provided at 0.5 sq. ft. per bird during the brooding period (Phase 1: days 1–21) and 1.0 sq. ft. per bird during the grower–finisher phase (Phase 2: days 22–42). The experimental shed was thoroughly washed with water, followed by disinfection with phenyl solution, and left to dry for 24 h. Sun-dried wooden shavings were used as litter material at a thickness of 2 inches, with 2% limestone added as a disinfectant. During the brooding period (weeks 1–3), ambient temperature was maintained at 90–95 °F during the first week using electric brooders fitted with 40/60-watt bulbs. On the first day, chicks were offered sugar water for initial flushing. Feed and fresh water were provided *ad libitum* throughout the trial. Each group was provided with two feeders and two drinkers. Feed and water refusals were weighed and recorded daily in the morning. A 22-hour lighting schedule was maintained throughout the experimental period, with bulbs suspended at a height of 8 feet. All recommended vaccination schedules were followed as per the guidelines of the Department of Poultry Husbandry, Sindh Agriculture University, Tandojam.

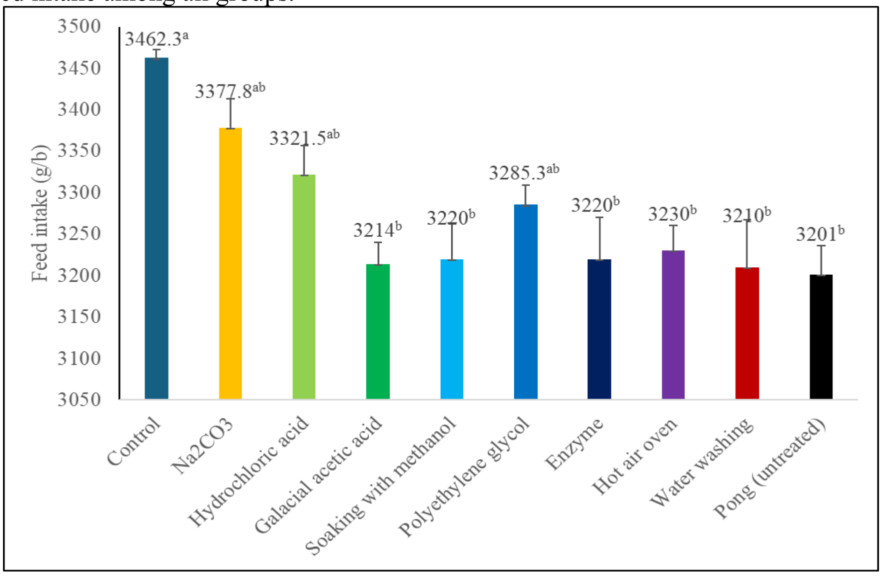
Growth Parameters

Feed Intake

Total feed intake was determined by offering pre-weighed feed *ad libitum* twice daily at six-hour intervals. Feed refusal was weighed daily, and feed intake was calculated using the following formula:
Feed intake (g/bird/day) = Total feed offered (g) – Total feed refused (g/group/day)

Live Body Weight
Five birds were randomly selected from each replicate, individually identified, and weighed weekly using a digital weighing balance. Initial body weight was recorded at day 1, and subsequent weights were taken at weekly intervals until the end of the trial.
Feed Conversion Ratio (FCR)
Feed conversion ratio was computed as the amount of feed consumed per unit of body weight gain, using the following formula:
FCR = Total feed intake (g) / Total live body weight gain (g)
Carcass Weight (g/bird)
At the conclusion of the 42-day experimental period, four birds per replicate were randomly selected, individually weighed, and humanely slaughtered. Following evisceration, carcass weight (excluding head, feet, and internal organs) was recorded.
Dressing Percentage
Dressing percentage was calculated using the following formula:
Dressing (%) = (Carcass weight / Total live body weight) × 100
Internal Organ Weight (%)
The relative weights of internal organs (liver, spleen, heart, and gizzard) were recorded from four slaughtered birds per replicate. Organs were excised, cleaned of adhering fat and connective tissue, and weighed using an analytical balance. Relative organ weights were calculated as:
Relative organ weight (%) = (Organ weight / Total live body weight) × 100
Fat Pad (%)
Birds were humanely slaughtered, and the abdominal cavity was opened to carefully remove the fat pad (a yellowish mass of adipose tissue). The fat pad was weighed using an analytical balance, and its percentage was calculated as:
Fat pad (%) = (Fat pad weight / Total live body weight) × 100
Economics
At the end of the trial, an economic analysis was performed to assess the cost-effectiveness and net return associated with the inclusion of detoxified *Pongamia pinnata* seeds in broiler diets.
Statistical Design
All statistical analyses were performed using JMP software (SAS Institute Inc., Cary, NC, USA). Data were expressed as means ± standard error (SE). Comparisons among treatment means were conducted using one-way analysis of variance (ANOVA). Significant differences between means were determined using Tukey's multiple comparison test at a significance level of $p < 0.05$.

RESULTS
Feed intake
Results on the effect of detoxification of *Pongamia pinnata* seed on feed intake of broiler are presented in Figure 1. Data indicates that maximum feed intake (3462.3 g/b) was recorded in control group followed by broiler fed *Pongamia pinnata* detoxified with Na_2CO_3 (3377.8 g/b), hydrochloric acid (3321.5 g/b), polyethylene glycol (3285.3 g/b), hot air oven (3230 g/b), soaking with methanol (3220 g/b), enzyme (3220 g/b), galacial acetic acid (3214 g/b) and water washing (3210 g/b), respectively. Minimum feed intake (3201 g/b) was noted in broiler fed on *Pongamia pinnata* (without detoxification). Statistical analysis revealed that there was significant (P<0.05) difference in feed intake among all groups.

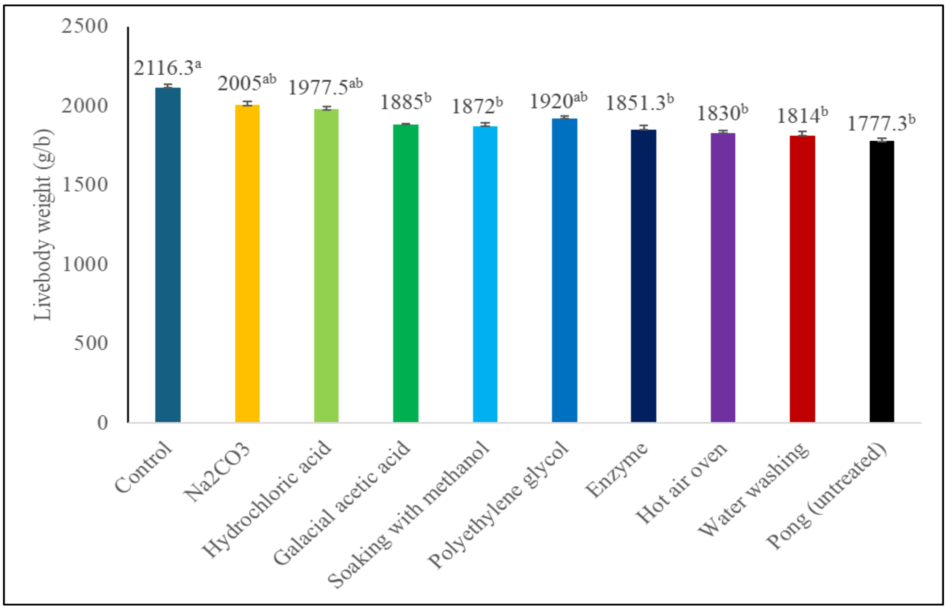


P-value: 0.0001

Figure 1. Effect of detoxification of *Pongamia pinnata* seed on feed intake (g/b) of broiler

Live body weight

Results on the effect of detoxification of *Pongamia pinnata* seed on live body weight of broiler are presented in Figure 2. Data indicates that maximum live body weight (2116.3 g/b) was recorded in control group followed by broiler fed on *Pongamia pinnata* detoxified with Na_2CO_3 (2005 g/b), hydrochloric acid (1977.5 g/b), polyethylene glycol (1920 g/b), galacial acetic acid (1885 g/b), soaking with methanol (1872 g/b), enzyme (1851.3 g/b), hot air oven (1830 g/b) and water washing (1814 g/b), respectively. Minimum live body weight (1777.3 g/b) was noted in broiler fed on *Pongamia pinnata* (without detoxification). Statistical analysis revealed that there was significant (P<0.05) difference in live body weight among all groups.

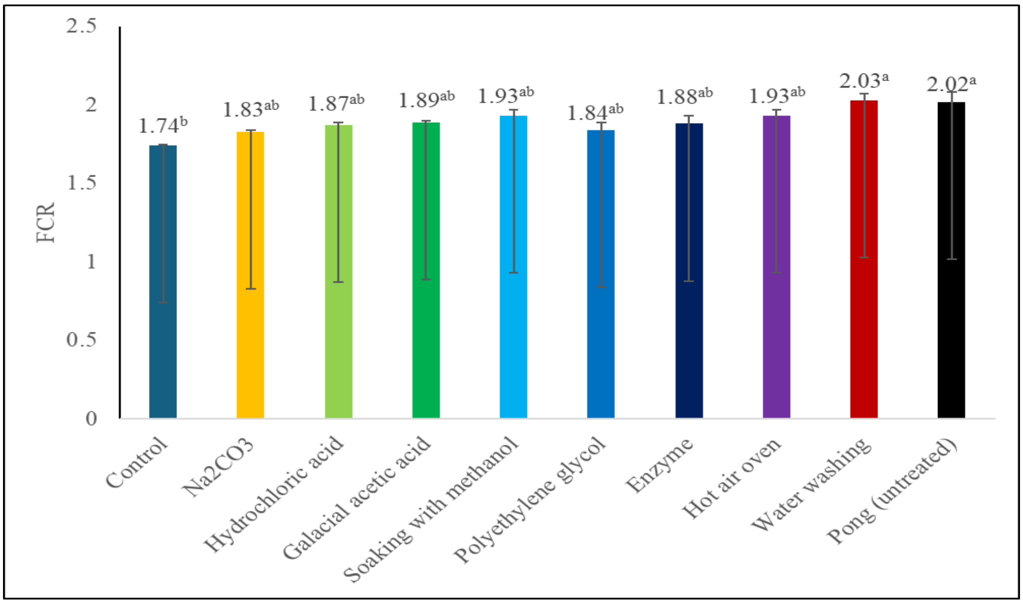


P-value: 0.0001

Figure 2. Effect of detoxification on live body weight (g/b) of broiler

Feed conversion ratio (FCR)

Results on the effect of detoxification of *Pongamia pinnata* seed on FCR of broiler are presented in Figure 3. Data indicated that better FCR (1.74) was recorded in control group by broiler fed on *Pongamia pinnata* detoxified with Na_2CO_3 (1.83), polyethylene glycol (1.84), hydrochloric acid (1.87), enzyme (1.88), galacial acetic acid (1.89), soaking with methanol (1.93) and hot air oven (1.93), respectively. Poor FCR (2.02 and 2.03) was noted in broiler fed on detoxified water washing and *Pongamia pinnata* (without detoxification). Statistical analysis revealed that there was significant (P<0.05) difference in FCR among all groups.



P-value: 0.0017

Figure 3. Effect of detoxification on FCR of broiler

Carcass weight

Results on the effect of detoxification of *Pongamia pinnata* seed on carcass weight of broiler are presented in Table 3. Data indicates that maximum carcass weight (1441.75±25.13g/b) was recorded in control group by broiler fed on *Pongamia pinnata* detoxified with Na_2CO_3 (1410.75±24.91g/b), hydrochloric acid (1314.25±24.60g/b), galacial acetic acid (1186.25±45.71g/b), soaking with methanol (1097.75±58.84 g/b), polyethylene glycol (1055.75±43.03g/b), enzyme (1000.00±14.85 g/b), hot air oven (867.75±44.65g/b) and water washing (810.00±41.64g/b), respectively. Minimum carcass weight (764.00±50.81g/b) was noted in broiler fed on *Pongamia pinnata* (without detoxification). Statistical analysis revealed that there was significant ($P<0.05$) difference in carcass weight among all groups.

Dressing percentage

Results on the effect of detoxification of *Pongamia pinnata* seed on dressing percentage of broiler are presented in Table 3. Data indicates that maximum dressing (68.37±1.96%) was recorded in control group by broiler fed on *Pongamia pinnata* detoxified with Na_2CO_3 (66.51±2.58%), hydrochloric acid (65.20±0.61%), galacial acetic acid (63.24±1.00%), soaking with methanol (60.86±3.06%), polyethylene glycol (60.66±0.95%), enzyme (60.34±3.43%), hot air oven (57.55±2.17%) and water washing (56.24±2.89%), respectively. Minimum dressing (56.10±1.81%) was noted in broiler fed on *Pongamia pinnata* (without detoxification). Statistical analysis revealed that there was significant ($P<0.05$) difference in dressing percentage among all groups.

Fat pad

Results on the effect of detoxification of *Pongamia pinnata* seed on fat pad of broiler are presented in Table 3. Data indicates that maximum fat pad (0.38±0.13%) was recorded in control group by broiler fed on *Pongamia pinnata* detoxified with Na_2CO_3 (0.35±0.07%), hydrochloric acid (0.28±0.04%), galacial acetic acid (0.27±0.07%), soaking with methanol (0.27±0.03%), polyethylene glycol (0.26±0.04%), enzyme (0.26±0.03%), hot air oven (0.25±0.04%) and water washing (0.20±0.05%), respectively. Minimum fat pad (0.17±0.03%) was noted in broiler fed on *Pongamia pinnata* (without detoxification). Statistical analysis revealed that there was significant ($P<0.05$) difference in fat pad among all groups.

Table 3. Effect of detoxification on carcass weight (g/b), dressing (%) and fat pad (%) of broiler

Group	Treatment	Carcass weight (g/b)	Dressing (%)	Fat pad (%)
T0	Control	$1441.75±25.13^{a}$	$68.37±1.96^{a}$	$0.38±0.13^{a}$
T1	Na_2CO_3	$1410.75±24.91^{a}$	$66.51±2.58^{ab}$	$0.35±0.07^{ab}$
T2	Hydrochloric acid	$1314.25±24.60^{b}$	$65.20±0.61^{ab}$	$0.28±0.04^{cd}$
T3	Galacial acetic acid	$1186.25±45.71^{c}$	$63.24±1.00^{bc}$	$0.27±0.07^{bcd}$
T4	Soaking with methanol	$1097.75±58.84^{d}$	$60.86±3.06^{cd}$	$0.27±0.03^{bcd}$
T5	Polyethylene glycol	$1055.75±43.03^{de}$	$60.66±0.95^{cd}$	$0.26±0.04^{bcd}$
T6	Enzyme	$1000.00±14.85^{e}$	$60.34±3.43^{c}$	$0.26±0.03^{bc}$
T7	Hot air oven	$867.75±44.65^{f}$	$57.55±2.17^{e}$	$0.25±0.04^{bc}$
T8	Water washing	$810.00±41.64^{g}$	$56.24±2.89^{de}$	$0.20±0.05^{cd}$
T9	Pong (untreated)	$764.00±50.81^{g}$	$56.10±1.81^{e}$	$0.17±0.03^{d}$
P-value		0.0001	0.0001	0.0050
SE±		28.101	1.5879	0.0458
LSD		57.389	3.2429	0.0935

Relative weight of liver

Results on the effect of detoxification of *Pongamia pinnata* seed on relative weight of liver in broiler are presented in Table 4. Data indicates that maximum relative weight of liver (3.38±0.21%) was recorded in broiler fed on *Pongamia pinnata* (without detoxification) followed by broiler fed on *Pongamia pinnata* detoxified water washing (2.60±0.04%), hot air oven (2.39±0.14%), enzyme (2.30±0.13%), polyethylene glycol (2.29±0.11%), soaking with methanol (2.29±0.09%), galacial acetic acid (2.25±0.15%), hydrochloric acid (2.25±0.08%) and Na_2CO_3 (2.17±0.10%), respectively. Minimum relative weight of liver (1.94±0.08%) was recorded in control group. Statistical analysis revealed that there was significant ($P<0.05$) difference in relative weight of liver among all groups.

Relative weight of spleen

Results on the effect of detoxification of *Pongamia pinnata* seed on relative weight of spleen in broiler are presented in Table 4. Data indicates that relative weight of spleen in group control (0.17±0.01%), *Pongamia pinnata* seed detoxified with Na_2CO_3 (0.20±0.01%), hydrochloric acid (0.17±0.02%), galacial acetic acid (0.20±0.03%), soaking with methanol (0.20±0.01%), polyethylene glycol (0.18±0.02%), enzyme, (0.22±0.01%), hot air oven (0.20±0.01%), water washing (0.20±0.02%) and *Pongamia pinnata* (without detoxification) (0.26±0.01%), respectively. Statistical analysis revealed that there was a non-significant ($P>0.05$) difference in relative weight of spleen among all groups.

Relative weight of heart

Results on the effect of detoxification of *Pongamia pinnata* seed on relative weight of heart in broiler are presented in Table 4. Data indicates that relative weight of heart in group control (0.30±0.03%), *Pongamia pinnata* seed detoxified with Na_2CO_3 (0.32±0.07%), hydrochloric acid (0.34±0.05%), galacial acetic acid (0.35±0.05%), soaking with methanol (0.36±0.03%), polyethylene glycol (0.35±0.06%), enzyme, (0.37±0.03%), hot air oven (0.39±0.03%), water washing (0.40±0.02%) and *Pongamia pinnata* (without detoxification) (0.38±0.04%), respectively. Statistical analysis revealed that there was non-significant (P>0.05) difference in relative weight of heart among all groups.

Relative weight of gizzard

Results on the effect of detoxification of *Pongamia pinnata* seed on relative weight of gizzard in broiler are presented in table 4. Data indicates that relative weight of gizzard in group control (1.34±0.03%), *Pongamia pinnata* seed detoxified with Na_2CO_3 (1.34±0.04%), hydrochloric acid (1.31±0.07%), galacial acetic acid (1.36±0.05%), soaking with methanol (1.37±0.06%), polyethylene glycol (1.39±0.04%), enzyme, (1.36±0.05%), hot air oven (1.35±0.05%), water washing (1.36±0.03%) and *Pongamia pinnata* (without detoxification) (1.36±0.07%), respectively. Statistical analysis revealed that there was non-significant (P>0.05) difference in relative weight of gizzard among all groups.

Table 4. Effect of detoxification on relative weight of organs (%) of broiler

Group	Treatment	Liver (%)	Spleen (%)	Heart (%)	Gizzard (%)
T0	Control	1.94±0.08^{e}	0.17±0.01	0.30±0.03	1.34±0.03
T1	Na_2CO_3	2.17±0.10^{cd}	0.20±0.01	0.32±0.07	1.34±0.04
T2	Hydrochloric acid	2.25±0.08^{cd}	0.17±0.02	0.34±0.05	1.31±0.07
T3	Galacial acetic acid	2.25±0.15^{c}	0.20±0.03	0.35±0.05	1.36±0.05
T4	Soaking with methanol	2.29±0.09^{b}	0.20±0.01	0.36±0.03	1.37±0.06
T5	Polyethylene glycol	2.29±0.11^{cd}	0.18±0.02	0.35±0.06	1.39±0.04
T6	Enzyme	2.30±0.13^{d}	0.22±0.01	0.37±0.03	1.36±0.05
T7	Hot air oven	2.39±0.14^{cd}	0.20±0.01	0.39±0.03	1.35±0.05
T8	Water washing	2.60±0.04^{cd}	0.20±0.02	0.40±0.02	1.36±0.03
T9	Pong (untreated)	3.38±0.21^{a}	0.26±0.01	0.38±0.04	1.36±0.07
P-value		0.0001	0.1970	0.2500	0.7798
SE±		0.0886	0.0302	0.0360	0.0397
LSD		0.1809	0.0617	0.0736	0.0812

Mortality

Results on the effect of detoxification of *Pongamia pinnata* seed on mortality (%) of broiler are presented in table 5. Data indicates that mortality was recorded as 5% in control group, Na^2CO^3 treated group, Polyethylene glycol and Enzyme treated group. Whereas mortality was recorded as 7.5% in broiler fed on detoxified Hydrochloric acid, Galacial acetic acid, soaking with methanol, Hot air oven and Water washing, respectively.

Table 5. Effect of detoxification on mortality (%) of broiler

Group	Treatment	Mortality (%)
T0	Control	2(5%)
T1	Na_2CO_3	2(5%)
T2	Hydrochloric acid	3(7.5%)
T3	Galacial acetic acid	3(7.5%)
T4	Soaking with methanol	3(7.5%)
T5	Polyethylene glycol	2(5%)
T6	Enzyme	2(5%)
T7	Hot air oven	3(7.5%)
T8	Water washing	3(7.5%)
T9	Pong (untreated)	3(7.5%)

DISCUSSION

Feed intake is a fundamental determinant of growth performance and productive efficiency in broiler production, governed largely by feed palatability, nutrient density, and the presence of anti-nutritional factors (Predescu et al.,2024; Ahiwe et al.,2018). In the present study, detoxification of *Pongamia pinnata* seeds significantly enhanced feed intake across all treated groups compared to the untreated control. Among the various detoxification strategies, sodium carbonate (Na_2CO_3) treatment elicited the most pronounced improvement in feed consumption, which may be attributed to its superior capacity to neutralize tannins and other phenolic compounds, thereby reducing astringency and improving palatability (Jesus et al.,2025; Diribi et al.,2025). Acid-based treatments (hydrochloric acid and glacial acetic acid), methanol soaking, polyethylene glycol (PEG), enzymatic digestion, and thermal processing also demonstrated variable degrees of efficacy. These methods function by disrupting or inactivating anti-nutritional factors such as saponins, phorbol esters, and condensed tannins, which are known to interfere with nutrient absorption and reduce feed palatability (Han et al.,2026; Ali et al., 2022). Notably, the enhanced feed intake observed with acid and solvent treatments suggests their potential utility in optimizing the nutritional value of unconventional feed resources [Katu et al., 2025);(Maksimenko et al.,2024). The persistence of reduced feed intake in birds fed untreated seeds underscores the critical role of adequate detoxification in rendering *P. pinnata* seeds suitable for poultry feeding.

Live body weight serves as a direct indicator of growth performance and reflects the cumulative effects of dietary nutrient availability and metabolic efficiency (Patience et al.,2015; Rosenfeld et al., 2015). Detoxification of *P. pinnata* seeds consistently improved live body weight in broilers relative to the untreated group, with Na_2CO_3 treatment yielding the highest weight gains. This response is plausibly linked to the effective neutralization of anti-nutritional factors, particularly tannins and phorbol esters, which are known to inhibit digestive enzyme activity and reduce protein bioavailability (Patience et al., 2015); (Rosenfeld et al., 2015). Acid treatments (hydrochloric acid and glacial acetic acid) also improved body weight, likely through the hydrolysis of complex polysaccharides and the disruption of protein–tannin complexes, thereby enhancing nutrient digestibility (Fonseca et al.,2023);(Besharat et al.,2022). Methanol soaking, PEG, enzymatic treatment, and heat application contributed to moderate improvements by partially mitigating the adverse effects of anti-nutritional compounds and improving feed palatability (ibiloye Balogun et al., 2026)(Attia-Ismail et al., 2015). These findings collectively indicate that detoxification processes are indispensable for unlocking the nutritional potential of *P. pinnata* seeds, enabling their effective integration into broiler diets as a sustainable protein source (Hagag et al., 2025; Yang)(Chisoro et al., 2025).

Feed conversion ratio (FCR) is a critical efficiency metric in poultry production, directly influencing economic viability (Adaszyńska-Skwirzyńska et al.,2025; Gao et al.,2025). The present study demonstrated that detoxification of *P. pinnata* seeds significantly improved FCR compared to the untreated group, with Na_2CO_3 treatment producing the most favorable values. This improvement is likely attributable to enhanced nutrient digestibility and reduced metabolic waste resulting from the elimination of anti-nutritional factors (Han et al.,2026., Cao,et al.,2024). Acid treatments (hydrochloric acid and glacial acetic acid) also yielded superior FCR, reflecting their efficacy in breaking down complex anti-nutritional components and facilitating nutrient absorption (Mugoti et al.,2025., Hilly et al., 2022). Methanol soaking, PEG, enzymatic treatment, and heat processing further illustrated the potential of detoxification strategies to optimize FCR, albeit to a lesser extent (Öz et al.,2026;(Choudhury et al.,2025) The poor FCR observed in birds fed untreated *P. pinnata* seeds highlights the metabolic cost imposed by anti-nutritional compounds, which increase feed wastage and reduce growth efficiency. These results underscore the necessity of employing robust detoxification protocols to maximize the utility of *P. pinnata* as a feed ingredient (Sagar, et al., 2025; Kazemi et a.,2025).

Carcass weight is a critical determinant of broiler productivity and directly influences farm profitability (Suliman et al.,2026; Yeter et al.,2026; Ramukhithi et al.,2023). In this study, detoxification of *P. pinnata* seeds significantly improved carcass weight compared to the untreated group, with Na_2CO_3 treatment yielding the highest carcass weight among treated groups. This improvement is likely mediated by the enhanced nutrient absorption and reduced metabolic interference resulting from the neutralization of anti-nutritional compounds (Khani et al.,2026; Duraiswamy et al.,2023). Acid treatments (hydrochloric acid and glacial acetic acid) also contributed to improved carcass weight, consistent with their ability to degrade anti-nutritional components and enhance nutrient availability (Saminathan et al.,2022). Methanol soaking, PEG, enzymatic treatment, and heat processing provided moderate improvements by reducing the detrimental effects of anti-nutritional factors (Ahmad et al.,2025; Samtiya et al.,2020). The markedly lower carcass weight in birds fed untreated seeds reinforces the importance of detoxification for optimizing meat yield and ensuring economic sustainability in broiler operations (Sugiharto et al.,2026; Abd El-Hack et al.,2026).

Dressing percentage is a key indicator of edible meat yield and reflects the overall efficiency of nutrient utilization (Anaso et al.,2025; Anaso et al.,2025). In the present study, detoxification treatments significantly influenced dressing percentage, with the control group exhibiting the highest values, followed by Na_2CO_3, hydrochloric acid, and glacial acetic acid treatments. This pattern aligns with previous findings indicating that effective detoxification mitigates the adverse effects of anti-nutritional factors, thereby improving carcass quality (Rao et al.,2013). The superior dressing percentage observed with Na_2CO_3 treatment likely results from the comprehensive neutralization of harmful compounds that interfere with nutrient metabolism (Azizi-Mehr et al.,2024). Methanol soaking, PEG, and enzymatic treatments yielded moderate improvements, suggesting partial alleviation of anti-nutritional effects, whereas heat processing and water washing were comparatively less effective (Dordevic et al.,2025; Soni et al.,2022). The lowest dressing percentage in birds fed untreated seeds underscores the critical role of detoxification in optimizing meat yield and supporting sustainable poultry production (Akter et al.,2025)

Abdominal fat pad weight serves as a valuable indicator of energy balance and lipid metabolism in broilers (Bai et al.,2021). In this study, detoxification of *P. pinnata* seeds significantly modulated fat pad deposition, with the control group exhibiting the highest fat pad percentage (0.38%), followed by Na_2CO_3 (0.35%), hydrochloric acid (0.28%), and glacial acetic acid (0.27%). The reduction in fat pad weight with acid treatments reflects improved nutrient utilization and reduced metabolic inefficiency (Singh et al., 2020; verma et al., 2019). Methanol soaking (0.27%), PEG (0.26%), and enzymatic treatment (0.26%) resulted in moderate reductions, indicating partial mitigation of anti-nutritional effects (Zayed et al.,2025; Kemal et al.,2025). Interestingly, heat processing (0.25%) and water washing (0.20%) yielded the lowest fat pad weights, suggesting that these methods were most effective in limiting fat accretion, possibly due to reduced nutrient availability (Manoharan et al.,2024). The untreated group exhibited the lowest fat pad weight (0.17%), likely reflecting poor nutrient utilization rather than metabolic efficiency. These findings highlight the dual role of detoxification in not only improving growth performance but also modulating fat deposition, contributing to healthier and more efficient poultry production (Naeem et al.,2025; Tang et al.,2026).

In conclusion, the present study provides robust evidence that detoxification of *Pongamia pinnata* seeds, particularly with sodium carbonate, significantly enhances growth performance, feed efficiency, carcass traits, and metabolic health in broiler chickens. These findings position detoxified *P. pinnata* seeds as a viable, sustainable, and cost-effective alternative protein source for poultry diets, contributing to food security and environmental sustainability. Further research is warranted to optimize detoxification protocols and evaluate long-term effects on broiler health and product quality.

CONCLUSIONS

This study confirms that detoxification of *Pongamia pinnata* seeds significantly improves growth performance, feed efficiency, and carcass traits in broiler chickens. Among all detoxification methods evaluated, sodium carbonate (Na_2CO_3) treatment proved most effective, yielding the highest feed intake, live body weight, best feed conversion ratio, and superior carcass and dressing percentages.The effectiveness of Na_2CO_3 is attributed to its superior ability to neutralize anti-nutritional factors such as tannins, saponins, and phorbol esters, thereby enhancing nutrient digestibility and metabolic efficiency. Acid-based treatments (hydrochloric acid and glacial acetic acid) also demonstrated considerable efficacy, while methanol soaking, polyethylene glycol, enzymatic treatment, and thermal processing provided moderate improvements.

Reduced relative liver weight in detoxified groups indicated alleviation of hepatic stress, confirming the safety of treated seeds. The non-significant differences in spleen, heart, and gizzard weights across all groups further confirmed that detoxification does not adversely affect vital organ development. Mortality was lowest (5%) in birds fed Na_2CO_3, polyethylene glycol, and enzyme-treated diets.

Economically, the inclusion of detoxified *P. pinnata* seeds offers a viable strategy to reduce dependence on expensive conventional protein sources, thereby lowering feed costs and enhancing profitability. From a sustainability perspective, utilizing this underutilized oilseed resource supports circular agriculture, reduces food-feed competition, and minimizes environmental footprints.

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