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Effects of dietary insoluble fibre supplementation on nutrient digestibility and livability in commercial broiler chicken

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Abstract
This study conducted to assess the effects of dietary insoluble fibre supplementation on nutrient digestibility (retention) and livability in commercial broiler chickens. A total of 160 day-old Vencobb 430Y broiler chicks were randomly assigned to five treatment groups, each consisting of four replicates with eight birds per replicate. The level of supplementation of insoluble fibre was 0%, 0.25%, 0.50%, 0.75% and 1% resulting in treatments T_1 (basal diet), T_2 (basal diet + 0.25% insoluble fibre), T_3 (basal diet + 0.50% insoluble fibre), T_4 (basal diet + 0.75% insoluble fibre) and T_5 (basal diet + 1% insoluble fibre) throughout the experimental period of 42 days. The results revealed that, retention of dry matter, organic matter, crude fat, crude fibre, NDF and ADL did not differ significantly among treatments. In contrast, ADF retention was significantly higher ($p<0.05$) in the 1% insoluble fibre supplemented group compared to T_1 and T_2. Nitrogen and calcium balances were similar across all groups, while phosphorus balance was significantly increased ($p<0.05$) at the 1% supplementation level relative to the control (T_1) and T_2 groups. Livability remained statistically similar throughout the experimental period. The results suggest that insoluble fibre supplementation did not markedly affect overall nutrient retention; however, higher supplementation level improved phosphorus and ADF retention.

Keywords: Insoluble fibre, nutrient retention, metabolic trial, gizzard development, mineral balance, Livability

1. Introduction
In the early stages of chick development, the gastrointestinal tract has limited capacity to process feed particles of varying size, making the use of finely ground ingredients essential (Uni *et al.*, 1999) [12]. However, diets containing a high proportion of fine particles can adversely affect gizzard development (Abdollahi *et al.*, 2013) [1]. An underdeveloped gizzard accelerates the passage of undigested material from the foregut to the hindgut, thereby reducing feed efficiency (Wiernusz *et al.*, 1995; Drozd *et al.*, 2022) [13, 5]. Furthermore, undigested proteins that reach the hindgut undergo microbial fermentation, producing ammonia, indoles, phenols, and amines-compounds known to impair growth performance and intestinal morphology in broilers (Qaisrani *et al.*, 2015) [10]. To counter these limitations, several strategies have been explored to enhance foregut function, including the incorporation of coarsely ground ingredients and insoluble dietary fibre (IDF) (Hetland *et al.*, 2005) [7]. Previous research has demonstrated that IDF reduces hindgut protein fermentation, prolongs digesta retention, stimulates gizzard activity, and increases hydrochloric acid secretion from the proventriculus (Kim *et al.*, 2008) [9]. Elevated HCl production lowers intestinal pH, thereby improving digestive enzyme activity and enhancing nutrient digestibility (Guinotte *et al.*, 1995; Alshamiri *et al.*, 2021) [6, 2]. In view of these functional benefits, the present study was designed to investigate the influence of dietary insoluble fibre supplementation on nutrient digestibility (retention) and livability in commercial broilers.

2. Materials and Methods
The trial was conducted in the months of July-August at Veterinary College, Anand, Gujarat, India. Ethical approval for the experiment was obtained from the Institutional Animal Ethics Committee (IAEC Approval No. 451/AN/24).

The experimental birds were reared at the Poultry Research Station, Anand, and samples were analysed at the Animal Nutrition Research Station, Anand.

2.1 Birds, Housing and Treatments

A total of 160 day-old Vencobb 430Y broiler chicks from a single hatch were obtained from Venkateshwara Hatcheries Pvt. Ltd., Anand, Gujarat. At placement, the chicks displayed statistically comparable initial body weights, ensuring homogeneity across treatment groups. Birds were randomly assigned to five dietary treatments, each consisting of four replicates with eight chicks per replicate (n = 32 per treatment). The experimental design evaluated the influence of increasing levels of dietary insoluble fibre supplementation. The dietary treatments included: T_1 (basal diet), T_2 (basal diet + 0.25% insoluble fibre), T_3 (basal diet + 0.50% insoluble fibre), T_4 (basal diet + 0.75% insoluble fibre) and T_5 (basal diet + 1% insoluble fibre). These diets were provided throughout the 42-day feeding trial. The commercial insoluble fibre product used in the study contained approximately 81% NDF, 68% ADF, and 22% ADL. All diets were formulated according to BIS (2024) specifications for the starter (1-10 days), grower (11-21 days), and finisher (22-42 days) phases. Details of the ingredient and chemical composition of experimental diets at different phases are presented in Table 1.

Table 1: Ingredients and chemical composition of the experimental diet at different phases

Ingredients (%)	Name of Mash		
	Broiler Starter	Broiler Grower	Broiler Finisher
Maize	53.510	58.147	62.439
Soyabean DOC	40.569	35.843	31.497
Calcite Powder	1.320	1.388	1.456
DCP	1.008	0.960	0.908
Vitamins	0.050	0.050	0.050
Vitamin-B12	0.010	0.010	0.010
Trace Minerals	0.100	0.100	0.100
Choline Chloride-60%	0.120	0.120	0.120
Lysine	0.302	0.292	0.146
Methionine	0.357	0.346	0.302
L-Threonine	0.106	0.078	0.086
Phytase-5000	0.010	0.010	0.010
Enzymes	0.020	0.020	0.020
Salt	0.250	0.250	0.250
Livertonic	0.100	0.100	0.100
Immunomodulator	0.050	0.050	0.050
Toxin Binder	0.100	0.100	0.100
Emulsifier	0.048	0.048	0.048
Probiotic	0.050	0.050	0.050
Anticoccidial	0.050	0.050	0.050
Vegetable Oil	1.870	1.988	2.208
Calculated nutrient analysis			
CP (%)	22.47	20.95	19.46
ME (kcal/kg feed)	3000.05	3050.05	3099.98
EE (%)	4.24	4.63	4.69
CF (%)	4.41	4.56	4.81
Ca (%)	1.59	1.52	1.74
P (%)	0.77	0.74	0.83
NDF (%)	11.61	11.52	11.70
ADF (%)	5.01	4.98	5.09
ADL (%)	0.67	0.65	0.69

Chemical composition: CP, crude protein; ME, metabolisable energy; EE, ether extract; CF, crude fibre; Ca, calcium; P, phosphorus; NDF, neutral detergent fibre; ADF, acid detergent fibre; ADL; acid detergent lignin.

Throughout the experimental period, feed and water were given *ad libitum* to the chicks. Brooding conditions were standardised by preheating the pens; brooder bulbs were switched on 12 hours prior to chick placement to achieve an initial temperature of 95°F during the first week. Thereafter, the brooding temperature was reduced by approximately 5°F each week until reaching 75°F. Chick behaviour beneath the brooder was closely monitored to assess comfort and to make any necessary adjustments to maintain optimal brooding conditions.

2.2 Metabolic Trial

A metabolic trial was carried out during the 6th week of the experiment using one bird from each replicate. The procedure included a two-day adaptation period followed by three-day total collection period. To enable accurate measurement of nutrient utilisation, the selected birds were relocated from group deep-litter system to individual deep-litter system, where they were provided feed and water individually throughout the trial. During the collection period, the amounts of feed offered, left over, and excreta voided were carefully recorded. Excreta were collected using pre-weighed and labelled plastic sheets placed beneath each bird, above the litter material. One-third of each excreta sample was preserved in concentrated H_2SO_4 for nitrogen estimation, while the remaining portion was oven-dried to determine dry matter. Samples from the three collection days were pooled per bird, ground uniformly, and stored for subsequent analysis. Feed offered, feed left over, and excreta samples were analysed for proximate composition and van soest analysis. Nitrogen estimation of the preserved acid-treated excreta was performed using the Kjeldahl method (AOAC, 2000) [3]. Calcium was analysed following ISI (1962) guidelines, and phosphorus concentrations were measured spectrophotometrically using a BIOMATE 3S Spectrophotometer (Thermo Fisher) according to AOAC (2000) [3].

2.3 Statistical analysis

The data obtained from various experimental observations was subjected to statistical evaluation. Analyses were conducted following a Completely Randomized Design (CRD), as described by Snedecor and Cochran (2014) [11]. Means of replicates within each treatment were considered for the analysis. Statistical computations were performed using the Statistical Package for the Social Sciences (SPSS, Versions 27).

3. Results and Discussion

3.1 Nutrient Digestibility (Retention)

The effects of dietary supplementation of insoluble fibre on nutrient balance are presented in Table 2. The mean values of nitrogen and calcium balance were statistically non-significant ($p>0.05$) among the treatments; however, numerically higher values were observed in groups receiving insoluble fibre supplementation. Phosphorus balance was significantly higher ($p<0.05$) in bird fed 1% insoluble fibre compared to those receiving 0.25% supplementation and the control diet. Non-significant differences ($p>0.05$) were observed among treatments for dry matter, organic matter, crude fat and crude fibre retention. Neutral detergent fibre (NDF) retention was numerically improved as the level of insoluble fibre in the diet increased. Acid detergent fibre (ADF) retention was significantly higher ($p<0.05$) in the 1% insoluble fibre supplemented group compared to control and 0.25% insoluble fibre supplementation. Acid detergent lignin (ADL) retention remained statistically similar ($p>0.05$) across treatments (Table 3).

The outcomes of the present study are consistent with earlier reports demonstrating effects of insoluble fibre supplementation on nutrient retention. Similar to our findings, Mousavi *et al.* (2024) [14] and Kheravii *et al.* (2017) [15] reported non-significant ($p>0.05$) differences of 1% lignocellulose supplementation on crude protein retention. Likewise, Kardel *et al.* (2025) [16] noted no any significant difference ($p>0.05$) in dry matter retention when diets were supplemented with rice hulls or sugar beet pulp, which supports the lack of treatment effect observed in the present trial. Findings by Adibmoradi *et al.* (2016) [18] regarding crude fat retention across varying levels (0.75% and 1.5%) of natural insoluble fibre supplementation further align with the non-significant treatment effects observed in the present study. Improvements in mineral utilisation observed in the present study are supported by the findings of Moradi *et al.* (2021) [17], who reported a significant increase ($p<0.01$) in phosphorus retention in broilers supplemented with insoluble fibre.

However, contrasting results were reported by Moradi *et al.* (2021) [17], who observed a significant improvement ($p<0.01$) in calcium retention in birds supplemented with 1% lignocellulose. Mousavi *et al.* (2024) [14], who reported a significant ($p<0.05$) increase in dry matter retention in broilers supplemented with 1% synthetic fibre compared to the control group. Zhang *et al.* (2023) [19], who observed that at higher levels of soya hull inclusion there was a significant ($p<0.05$) increase in crude fibre retention.

Table 2: Means of nitrogen, calcium and phosphorus balance (g/day/bird) during metabolic trial

Nutrient	Particulars	Treatment groups							
		T_1	T_2	T_3	T_4	T_5	SEm±	CD (0.05)	CV%
Nitrogen	Total Intake	3.14±0.14	3.89±0.23	3.71±0.37	3.52±0.32	3.12±0.13	0.26	NS	14.72
	Excreted faeces	0.05±0.00	0.12±0.04	0.09±0.03	0.07±0.01	0.08±0.02	0.03	NS	62.21
	Balance	3.09±0.14	3.77±0.23	3.62±0.34	3.46±0.31	3.05±0.13	0.24	NS	14.23
Calcium	Total Intake	1.66±0.08	1.98±0.14	1.94±0.22	1.72±0.19	1.73±0.07	0.15	NS	16.76
	Excreted faeces	0.68±0.05	0.66±0.09	0.68±0.28	0.49±0.05	0.56±0.10	0.14	NS	46.55
	Balance	0.98±0.07	1.32±0.07	1.26±0.10	1.23±0.14	1.18±0.09	0.10	NS	16.34
Phosphorus	Total Intake	0.80^{b}±0.04	1.03^{a}±0.06	1.09^{a}±0.08	1.12^{a}±0.07	1.16^{a}±0.02	0.06	0.17	10.88
	Excreted faeces	0.38±0.03	0.35±0.07	0.21±0.07	0.32±0.02	0.21±0.02	0.05	NS	32.85
	Balance	0.42^{c}±0.04	0.68^{b}±0.06	0.88^{ab}±0.12	0.80^{ab}±0.05	0.95^{a}±0.03	0.07	0.21	18.63

The means bearing different superscripts in the same row differ significantly ($p<0.05$).
T_1 (basal diet), T_2 (basal diet + 0.25% insoluble fibre), T_3 (basal diet + 0.50% insoluble fibre), T_4 (basal diet + 0.75% insoluble fibre) and T_5 (basal diet + 1% insoluble fibre); SEm ±, standard error of mean; CD, critical difference; CV%, coefficient of variation.

Table 3: Average nutrients retention (%) of experimental broilers during metabolic trail

Nutrient	Treatment groups							
	T_1	T_2	T_3	T_4	T_5	SEm±	CD (0.05)	CV%
Dry Matter	71.24±2.76	64.11±5.43	68.91±3.14	68.93±1.26	62.50±4.06	3.61	NS	10.75
Organic Matter	74.69±2.31	67.20±5.08	71.06±2.41	71.04±1.19	64.35±4.05	3.31	NS	9.50
Crude Fat	84.34±1.11	79.99±3.06	82.56±4.14	79.96±2.62	78.20±2.76	2.91	NS	7.17
Crude Fibre	37.98±2.51	35.71±5.65	37.41±4.69	34.31±4.71	33.10±7.61	5.30	NS	29.69
NDF	15.93±5.50	15.96±5.25	20.04±3.98	20.99±2.83	21.28±5.36	4.70	NS	49.88
ADF	3.01^{b}±0.80	3.13^{b}±0.73	4.30^{ab}±0.32	4.35^{ab}±0.29	5.55^{a}±0.24	0.53	1.62	26.20
ADL	0.78±0.11	0.82±0.14	0.96±0.06	0.86±0.04	1.03±0.05	0.09	NS	19.78

The means bearing different superscripts in the same row differ significantly ($p<0.05$).
T_1 (basal diet), T_2 (basal diet + 0.25% insoluble fibre), T_3 (basal diet + 0.50% insoluble fibre), T_4 (basal diet + 0.75% insoluble fibre) and T_5 (basal diet + 1% insoluble fibre); NDF, neutral detergent fibre; ADF, acid detergent fibre; ADL, acid detergent lignin; SEm ±, standard error of mean; CD, critical difference; CV%, coefficient of variation.

3.2 Livablity

The livability (%) in all the treatments were found to be statistically non-significant ($p>0.05$) and are presented in Table 4. Overall, the results indicate that dietary supplementation of insoluble fibre had no adverse effect on bird survivability, which was supported by Kheravii *et al.* (2017) [15], who observed no any significant ($p>0.05$) differences in livability between chicks supplemented with lignocellulose.

Table 4: Livability (%) of experimental broilers under feeding experiment

Livability (%)	Treatments					SEm±	CD (0.05)	CV%
	T_1	T_2	T_3	T_4	T_5			
	96.88	90.63	100.00	93.75	96.88	4.91	NS	10.265

T_1 (basal diet), T_2 (basal diet + 0.25% insoluble fibre), T_3 (basal diet + 0.50% insoluble fibre), T_4 (basal diet + 0.75% insoluble fibre) and T_5 (basal diet + 1% insoluble fibre).

4. Conclusion

Based on the above results, it is concluded that overall nutrient retention values remained unaffected across the treatments with insoluble fibre supplementation. However, phosphorus balance and acid detergent fibre (ADF) retention were improved at 1% insoluble fibre supplementation in the basal diet.

5. Acknowledgement

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Conflicts of Interest

The authors declare no conflicts of interest.

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