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Effect of dietary inclusion of maize gluten meal on performance, gut health, anti-oxidant status and carcass characteristics of Vencobb Broilers

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ABSTRACT

The present study evaluates the effect of replacing the dietary crude protein (CP) of vegetable source with that of maize gluten meal (MGM) on the performance, gut health and carcass composition of vencobb broilers. Two hundred day-old Vencobb chicks were randomly distributed into five treatments having four replicates of ten birds each. Treatments included CON: basal diet without MGM; MGM25: Replacement of 25% CP of vegetable source with MGM; MGM50: Replacement of 50% CP of vegetable source with MGM; MGM75: Replacement of 75% CP of vegetable source with MGM and; MGM100: Replacement of 100% CP of vegetable source with MGM. MGM25 birds had significantly ($p<0.05$) higher body weight gain (BWG) with the best FCR (1.69) among all the groups. Replacement of dietary vegetable protein with MGM above 50% led to significant ($p<0.05$) drop in BWG in comparison to CON. Ileal microbial plate count for E. coli and Lactobacillus were not affected ($p>0.05$) by the dietary inclusion of MGM. However, villus height, (VH, μ), villus height: villus width (VH: VW) and villus height: crypt depth (VH:CD) were improved in MGM25 and MGM50 groups compared to other groups. SOD and catalase activity was significantly higher ($p<0.05$) in MGM25. Eviscerated (dressed weight after removal of viscera) and drawn (eviscerated weight with giblets) percentage was severely affected above 50% replacement of vegetable source protein with MGM origin protein. Replacement of dietary vegetable protein with MGM protein at 25 % level yielded best results in terms of broilers' performance with maximum economic returns.

Keywords: Anti-oxidant Status, Broilers, Carcass, Gut health, Maize gluten meal

India is the fifth largest broiler meat producer with a tremendous annual growth of 12% in the Indian broiler industry (Prabakar *et al*. 2023). Protein concentrates are practically the second largest component of broilers ration after energy. Modern fast growing broiler chicken require higher levels of protein with balanced amino acids composition (Bhunia *et al*. 2023). Principal component of broiler diets is corn as energy and soybean meal as protein source with the addition of fats and oils (Rathaur *et al*. 2022). In India, conventionally, a limited number of protein sources are used by the commercial broiler industry to supply protein. Since, price of conventional protein sources like soybean meal has increased manifold, feed manufacturers have started exploring different viable alternate sources like DDGS and gluten meals (maize and rice) in poultry diets (Kaninde *et al*. 2023). Maize gluten meal(MGM), a by-product of wet milling of maize contains around 60% high quality crude protein comparable to that of animal source protein. It comprises primarily of zein (68%), glutelin (27%) and some globulins (1.2%) (Cha *et al*., 2000) and xanthophylls (up to 300 mg/g). It is also rich in methionine (Sasse and Baker, 1973) and contain highest known metabolizable protein value among plant proteins (Heuzé *et al*., 2015). Literature citing inclusion of MGM in broilers' diet is available (Abhijeet *et al*. 2021; Babcock *et al*. 2008 and Shariat *et al*. 2015) but, no study has so far been conducted on how much of the dietary protein from conventional vegetable sources can be replaced with that of MGM protein. Therefore, this study was carried out to assess the effect of dietary inclusion of MGM on the performance of Vencobb broiler chicken by replacing protein from other vegetable sources.

MATERIALS AND METHODS

The experiment was approved by Institutional Animal Ethic Committee meeting held in April 2022. Two hundred newly hatched Vencobb broiler chickens were procured from a local commercial hatchery vaccinated *in-ovo* against Marek diseases. Additionally, chicks were vaccinated against F-1 strain of NCD disease on 3rd day and IBD on 14th day. The birds were wing-tagged, weighed individually and randomly allocated to five pens (40 chicks per pen) representing different treatment groups *viz*. CON,

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Table 1. Nutrient composition of Maize gluten meal

Attributes	% level
Analysed	
Crude protein	60.07
Ether extract	1.78
Crude fibre	1.65
Leeson and summer (2005)	
Methionine	1.61
Lysine	0.90
Threonine	1.70

MGM25, MGM50, MGM75 and MGM100. All the pens were further divided in to four floor-spaces (replicates) of 10ft x10ft of 10 birds each. The birds were offered a 3-phase feeding program: a pre-starter diet from 0 to 7 d, a starter diet from 8 to 21 d and a finisher diet from 22 to 42 d. Diets were formulated to meet BIS (2007) requirements (table 2). CON group was fed basal diet containing no maize gluten meal (MGM). CP of vegetable origin i.e. soybean meal and groundnut cake was replaced with CP of MGM at 25, 50, 75 and 100% level in MGM25, MGM50, MGM75 and MGM100 group keeping all the diets iso-nitrogenous.

Table 2. Ingredient and nutrient composition of basal diets

Physical composition															
Ingredients (% as fed basis)	Pre-starter ration (0-7 days)					Starter ration (8-21days)					Finisher ration (22-42 days)				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Maize	49.61	50.36	52.60	56.07	58.54	50.60	52.60	55.56	58.55	59.54	54.58	56.56	58.55	60.51	63.02
Soybean meal	30.76	24.80	17.86	7.93	0.00	28.78	21.83	13.90	5.95	0.00	23.81	17.86	11.90	5.96	0.00
Groundnut cake	7.94	5.95	3.95	1.98	0.00	7.94	5.95	3.96	1.98	0.00	7.94	5.95	3.97	1.99	0.00
MGM (60%)	0.00	7.20	13.90	22.33	29.77	0.00	6.94	13.90	20.84	27.78	0.00	5.96	11.91	17.87	23.31
Fishmeal	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95
Vegetable oil	2.98	2.98	2.98	2.98	2.98	3.97	3.97	3.97	3.97	3.97	4.96	4.96	4.96	4.96	4.96
Mineral blend[1]	1.98	1.98	1.98	1.98	1.98	1.98	1.98	1.98	1.98	1.98	1.98	1.98	1.98	1.98	1.98
Agemix[2]	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Veldot[3]	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Choline (60%)	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Lysine (98%)	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
DL-Met (98%)	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Chlortetracycline	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Total	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Chemical composition															
Parameters	Pre-starter ration (0-7 days)					Starter ration (8-21days)					Finisher ration (22-42 days)				
Calculated Nutrients (%, DM basis except ME)															
ME (Kcal/kg)	2982	29.90	29.96	3007	3011	3067	3070	3084	3092	3105	3185	3190	3196	3205	3215
Dig. Lys	1.18	1.10	1.07	0.98	0.94	1.14	1.11	1.07	1.01	0.96	1.02	1.05	1.02	1.01	0.99
Dig. Met + Cys	0.75	0.78	0.80	0.82	0.85	0.75	0.76	0.78	0.81	0.83	0.69	0.71	0.73	0.76	0.79
Dig. Thr	0.76	0.73	0.79	0.76	0.77	0.73	0.69	0.72	0.77	0.73	0.66	0.62	0.65	0.61	0.67
Analysed nutrients (%, DM basis)															
Dry matter	89.88	89.16	90.10	89.70	90.22	89.82	90.25	88.96	89.35	90.05	89.85	90.08	89.20	89.17	89.80
Crude protein	22.85	22.13	22.54	22.48	22.32	21.90	21.38	21.56	22.05	21.72	20.00	20.56	20.48	20.34	21.11
Ether extract	4.26	4.80	4.10	4.05	411	5.35	5.31	5.26	5.20	5.18	6.42	6.34	6.25	6.28	6.19
Crude fibre	3.81	3.90	3.88	3.75	3.62	3.72	3.46	3.27	3.12	3.54	3.58	3.46	3.21	3.65	3.57
AIA	2.10	2.22	2.11	1.98	2.02	2.01	1.96	1.94	2.23	2.10	2.19	2.14	2.10	1.96	1.88
Ca	1.10	1.13	1.10	1.14	1.20	1.08	1.10	1.05	1.15	1.21	1.11	1.09	1.22	1.17	1.23
P	0.76	0.79	0.60	0.67	0.59	0.77	0.62	0.71	0.68	0.72	0.81	0.78	0.74	0.81	0.70
GE (kcal/kg)	4780	4795	4772	4766	4810	4634	4590	4622	4670	4785	4450	4394	4410	4445	4475

1: CON; 2: MGM25; 3: MGM50: 4: MGM75: 5: MGM100; [1]Each kg of mineral blend contained 300g Ca; 90g P, 4g Mg, 4g Zn, 0.; 1.0g I, 0.5g Cu and 2g Fe.; [2]Each 5kg Agemix (produced by Neospark Drugs and Chemicals Pvt. Ltd., India) contains Vitamin A: 12.5MIU; Vitamin D3: 2.5MIU; Vitamin E:8.0g; Vitamin K3: 1.0g; Vitamin B1: 800mg; Vitamin B2: 5.0g; Vitamin B6: 1.6g; Vitamin B12: 20.0mg; Niacin: 12.0g; Calcium d-Pantothenate: 8.0g; Folic Acid: 800.0mg; Biotin: 6.0mg; Choline Chloride: 300.0g; Calcium: 760.0g; Copper: 15.0g; Iodine: 1.0g; Iron: 60.0g; Manganese: 80.0g; Zinc: 80.0g and Selenium: 300.0mg).; [3]Veldot (produced by Venky India Ltd.) contains Dinitro-O-Toluamide, a coccidiostat.

Treatment diets were offered *ad libitum* throughout the trial period except for 10-h fasting period prior to slaughtering. The birds were monitored daily for general flock condition, temperature, lighting, water, feed, and any unanticipated events inside the poultry house. Wheat straw was used as litter material. Performance characteristics *viz*. feed intake (FI), body weight gain (BWG), feed conversion ratio (FCR) were calculated for 1-14, 15-28, 29-42 days as well as for the overall i.e. 1-42 days.

Analytical determinations of feeds and digesta were performed as per AOAC (2005). Gross energy content of feed and digesta was measured with digital bomb calorimeter (Tanco Bomb Calorimeter, P.L. Tandon & Co., New Delhi, India). Ca and P content of the feed was estimated as per the method of BIS (1992). At the completion of the feeding trial (42d), four birds from each replicate of different treatment groups were selected randomly and shifted to metabolic cages. These birds were fed weighed quantity of feed for 5 days. Amount of feed offered, leftover feed and faecal output was weighed daily and a representative sample of each was preserved for assessing gross energy metabolizabilty and nitrogen retention. After 5 days of metabolism study, these birds were sacrificed by cervical dislocation. After bleeding, birds were de-feathered after hot scalding at a temperature of 58° - 60°C and then, the carcasses were manually eviscerated and rinsed with water to assess carcass characteristics.

Samples were aseptically taken from 4 cm above the caecum, immediately frozen, and stored at –20°C until further processing for ileal microbiology and histology. Colony forming units (cfu) count of *E. coli* and *lactobacilli*, in the content of ileum was performed by selective growth medium. *E. coli* were counted after 24 to 48 h of incubation in MacConkey agar. Lactic acid bacteria were determined in MRS agar. The average number of colonies was multiplied by reciprocal of the dilution factor and expressed as log cfu/g of contents. Histological analysis was performed in tissue samples from ileum fixed by immersion in 10% formalin, paraffin-embedded, and sections stained with hematoxylin/ eosin (Luna, 1968). Measurements included villus height (VH, µm), villus width (VW, µm), crypt depth (CD, µm), villus height: villus width (VH: VW) and villus height: crypt depth (VH: CD). The villus height was measured from tip of the villus to the villus–crypt junction, and the crypt depth was defined as the invagination depth between adjacent villi. Crypt depth was measured as the invagination depth between neighbouring intestinal villi.

Statistical analysis of data was carried out with ANOVA using SPSS version 20.0 (IBM corp. USA). Duncan's post hoc multiple comparison (Duncan, 1955) was applied to separate means. Statistical differences were considered at $P<0.05$. For the microbiological data, the plate counts values were log-transformed.

RESULTS AND DISCUSSION

Birds fed MGM25 diet had significantly ($p<0.05$) higher BWG and feed intake in comparison to others (table 3). However, replacement of dietary vegetable protein with MGM @ 75% or above led to significant ($p<0.05$) drop in BWG which was anticipated to be due to reduced feed intake at these levels. FCR improved significantly ($p<0.05$) up to the replacement of 50% CP of vegetable source with MGM. Overall FCR was best (1.69) in MGM25 having 25% CP of MGM origin, which tended to increase as the replacement level of vegetable protein with MGM was increased. The decreased feed intake at higher levels of

Table 3. Performance of broiler chickens fed different diets

Treatment	CON	MGM25	MGM50	MGM75	MGM100
			Body weight gain (BWG), g		
1-14d	285.25^{c} ±7.69	450.70^{a} ±7.74	378.15^{b} ±3.49	141.80^{d} ±4.88	93.99^{e} ±3.31
15-28d	829.93^{c} ±7.60	923.45^{a} ±1.68	872.30^{b} ±6.48	230.28^{d} ±4.03	164.74^{e} ±5.52
29-42d	973.99^{c} ±1.10	1103.66^{b} ±4.50	1116.04^{a} ±1.58	197.09^{d} ±6.98	124.37^{e} ±0.71
1-42d	2089.18^{c} ±11.30	2477.89^{a} ±9.98	2366.50^{b} ±3.87	569.17^{d} ±3.92	383.11^{e} ±6.81
			Feed intake, g		
1-14d	438.29^{c} ±11.33	665.94^{a} ±14.25	565.74^{b} ±5.091	221.58^{d} ±7.49	145.48^{e} ±5.72
15-28d	1466.75^{b} ±10.29	1535.24^{a} ±7.38	1478.55^{b} ±12.62	406.83^{c} ±8.97	299.03^{d} ±8.91
29-42d	2016.67^{c} ±7.49	2144.50^{b} ±0.59	2213.54^{a} ±8.86	417.07^{d} ±13.67	266.33^{e} ±2.18
1-42d	3921.71^{c} ±22.11	4345.69^{a} ±20.95	4257.83^{b} ±7.57	1045.48^{d} ±10.98	710.85^{e} ±10.58
			FCR (g feed: g BWG)		
1-14d	1.54^{a} ±0.007	1.48^{b} ±0.012	1.49^{b} ±0.007	1.56^{a} ±0.013	1.55^{a} ±0.008
15-28d	1.76^{b} ±0.011	1.66^{d} ±0.007	1.69^{c} ±0.006	1.77^{b} ±0.011	1.82^{a} ±0.010
29-42d	2.07^{b} ±0.007	1.94^{d} ±0.008	1.98^{c} ±0.009	2.12^{a} ±0.014	2.14^{a} ±0.009
1-42d	1.79^{c} ±0.006	1.69^{e} ±0.005	1.72^{d} ±0.002	1.82^{b} ±0.009	1.83^{a} ±0.004
Viability (%)	97.50	97.50	97.50	80.00	72.50

Values bearing different superscripts in a row differ significantly.

Table 4. Ileal microbial count, intestinal morphology and anti-oxidant enzyme activity

	Treatments				
Variables	CON	MGM25	MGM50	MGM75	MGM100
Ileal microbial count					
E.coli (log cfu/g)	5.28±0.03	5.29±0.05	5.81±0.05	5.32±0.07	5.24±0.08
Lactobacillus (log cfu/g)	5.77±0.04	5.73±0.09	5.74±0.11	5.56±0.08	5.57±0.06
Histomorphometry of ileum					
VH, µ	1100.40^{b} ±8.81	1304.82^{a}±13.62	1283.53^{a}±13.88	416.60^{c}±12.24	305.81^{d} ±7.32
VW, µ	253.12^{a} ±5.93	208.68^{b} ±4.63	209.29^{b} ±7.64	221.21^{b}±7.43	200.16^{b}±11.05
CD, µ	251.20^{a} ±4.42	222.66^{b} ±4.19	227.94^{b} ±4.67	184.93^{c}±7.46	182.11^{c} ±5.56
VH:VW	4.36^{b} ±0.19	6.26^{a} ±0.10	6.18^{a} ±0.09	1.90^{c} ±0.14	1.56^{d} ±0.17
VH:CD	4.39^{b} ±0.11	5.88^{a} ±0.16	5.65^{a} ±0.17	2.27^{c} ±0.11	1.68^{d} ±0.06
Anti-oxidant enzyme activity					
SOD(U/mgHb)	25.51^{ab} ±0.16	25.90^{a} ±0.08	25.36^{b} ±0.15	22.27^{c} ±0.10	22.30^{c} ±0.20
Catalase(U/mgHb)	24.63^{b} ±0.14	25.51^{a} ±0.10	25.42^{a} ±0.08	20.77^{c} ±0.07	20.68^{c} ±0.05

Where, VH= Villus height; VW= Villus width; CD= Crypt depth.Values bearing different superscripts in a row differ significantly.

MGM might be due to its fairly unpalatable characteristics as reported by Blair (2008) and Abhijeet *et al*. (2021). Corn gluten meal above 10% in broiler diets leads to anti-nutritive effects of amino acid imbalance that reduces the feed intake of broiler chicks (Waldroup *et al*. 2002). Kang *et al*. (2022) also reported similar results at higher inclusion level of wheat gluten in chicks' diet. Viability of the birds was also decreased considerably at and above 75% replacement of GNC and SBM based protein with MGM protein which might be due to amino acid imbalance, especially lysine being mostly deficient in MGM based diets. Improved performance at lower MGM replacement level might be due to its higher methionine content (Sasse and Baker, 1973) and negative effects at higher replacement level might be due to decreased availability of other essential amino acid e.g. lysine and tryptophan (Vasal, 2000). A better gross energy metabolizability (figure 1) was observed in MGM25 (64.02%) and MGM50 (64.10%) than other groups. Percent nitrogen retention was not affected (p>0.05) up to 75% replacement of vegetable protein with MGM protein. Higher levels of MGM in broilers diet may reduce digestibility, resulting in growth depression as already reported by Babcock *et al*. (2008) and Shariat *et al*. (2015).

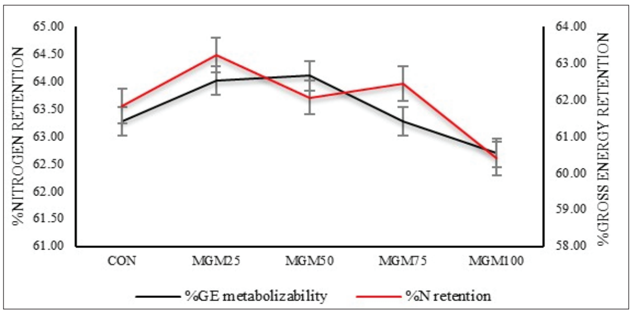

Fig. 1. Gross energy metabolizability and nitrogen balance under different treatments

Ileal microbial plate count (table 4) for *E. coli* and *Lactobacillus* did not differ (p>0.05) with the inclusion of MGM origin protein as reported earlier also by studies. However, ileal histomorphology (figure 2 and table 4) in terms of VH, (µ), VH:VW and VH:CD were improved significantly (p<0.05) in MGM25 and MGM50 as compared to other treatments. VW (µ) and CD (µ) decreased as the level of MGM was increased. Earlier studies show that higher levels of gluten meal upregulate the expression levels of interleukin-family genes (IL-12 and IL-8) leading to inflammatory changes and damage to villi length of broiler chickens as compared to lower inclusion levels (Kang *et al*., 2019). SOD and catalase activity was higher (p<0.05) in MGM25 comparative to others groups. The increased antioxidant activity may primarily be due to bioactive peptides released when its proteins are hydrolysed (Hu *et al*., 2020) leading to better performance by fighting oxidative stress, improved growth,

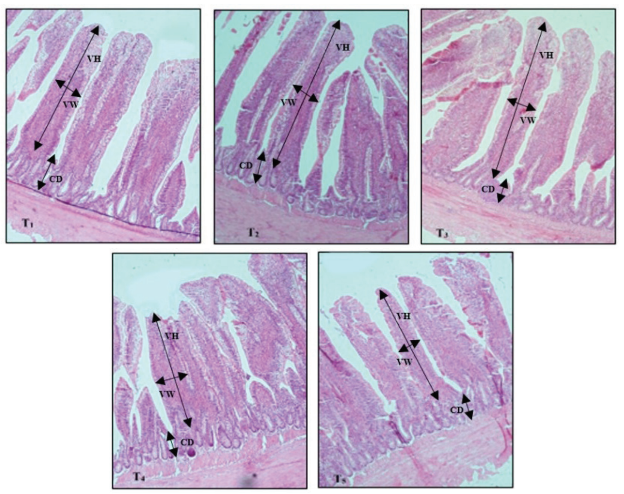

Fig. 2. Ileal histomorphology of birds under different treatment group

Table 5. Carcass characteristics of broiler chickens fed different diets

	Treatments				
Variables	CON	MGM25	MGM50	MGM75	MGM100
Dressed weight%*	77.99[a] ±0.23	79.37[a] ±0.15	78.18[a] ±0.35	42.50[b] ±0.97	40.61[c] ±0.84
Eviscerated weight%*	68.63[a] ±1.11	70.44[a] ±0.22	69.93[a] ±0.77	15.43[b] ±0.82	12.73[c] ±0.95
Drawn% *	75.19[a] ±1.12	76.74[a] ±0.22	76.35[a] ±0.76	20.16[b] ±0.84	17.46[c] ±0.91
Heart%	0.98[a] ±<0.05	0.95[ab]±<0.05	0.96[ab]±<0.05	0.93[b] ±<0.05	0.85[c] ±<0.05
Liver%	3.11[a] ±0.03	2.89[b] ±0.01	2.93[b] ±0.01	2.17[c] ±0.02	2.09[d] ±0.03
Gizzard%	2.46[a] ±0.02	2.45[a] ±0.01	2.52[a] ±0.02	1.78[b] ±0.03	1.62[c] ±0.02
Giblet%	6.56[a] ±0.06	6.30[b] ±0.02	6.42[b] ±0.02	4.88[c] ±0.05	4.56[d] ±0.04
Abdominal fat%	0.78[a]±<0.05	0.78[a] ±<0.05	0.78[a] ±<0.05	0.44[c] ±<0.05	0.48[b] ±<0.05

Values bearing different superscripts in a row differ significantly. *Dressed weight = Live weight - (blood + feathers + head shank + skin losses); Eviscerated weight = Dressed weight - weight of viscera; Drawn weight = Eviscerated weight + weight of giblets.

Table 6. Economics of feeding under different dietary treatments

Treatment	CON	MGM25	MGM50	MGM75	MGM100
Chick cost, Rs./bird*	36.92	36.92	36.92	45.00	49.66
Feed intake/bird, g	3922	4346	4258	1045	710
Feed cost, Rs./kg	38.67	39.46	40.00	40.41	41.18
Feed cost/bird, Rs.	151.66	171.49	170.32	42.23	29.23
Total production cost**, Rs.	188.58	208.41	207.24	87.23	78.89
Average market weight of bird, g	2138	2527	2415	619	432
Profit (+) or loss (-)/bird, Rs.***	3.84	+19.02	+10.11	-31.52	-40.01

*Cost of day old chick was Rs. 36.92. For calculating economics of feeding MGM at the end of experiment, cost of chick for different groups was calculated considering the number of mortality as follow: (no. of chicks at the start of experiment X cost of day old chick)/ no. of chicks at the end of experiment. **Total production cost includes cost of chicks and feed only. ***Sale price was Rs. 90/ kg bird.

feed efficiency and immune functions. The unaltered *E. coli* count due to a different protein source in the current study is supported by the fact that the growth of *E. coli* in the small intestine is independent of any exogenous amino acids availability (Apajalahti and Vienola, 2016). *Lactobacillus*, dependent on the availability of amino acid in small intestine (Morishita *et al*., 1981) remained unaffected in consistent to reports by Wani *et al*. (2017), Giannenas *et al*. (2017) and Dinani *et al*. (2018). Carcass characteristics (table 5) were not affected up to 50% vegetable protein MGM protein replacement. However, above 50% replacement level, there was a significant (P<0.05) negative impact on these carcass characteristics. Decreased growth performance and feed intake at and above 75% dietary inclusion of MGM protein in place of SBM and GNC might have resulted in the negative effects on the carcass characteristics of the broilers as also reported by Longo *et al*. (2007). Economics of raising broiler chickens (table 6) on various diets revealed that the MGM25 yielded the highest profit per bird. Inclusion of MGM protein above 50% is uneconomical due to decreased growth performance.

In conclusion, 25% replacement of dietary vegetable protein with MGM protein led to a 18.61% increase in BWG and the best FCR of 1.69 as compared to control without any unfavorable impacts on gut microflora and carcass charateristics of broiler chicken. The gut histomorphology, in terms of villus height and width and the economics returns of raising the broiler in terms of profit was highly improved in broilers fed 25% of dieatry protein from MGM. It was inferred that maize gluten meal (MGM) can serve as a novel and efficient substitute for conventional vegetable protein in poultry diets provided that the inclusion rate is given due deliberations.

REFERENCES

Abhijeet K, Prasanna S B, Mahesh P S, Ranjith R Y, Karan P, Bhandekar S K, Ali S M and Masood K D. 2021. Effect of Feeding Corn Gluten Meal in Feed Ration on Growth Performance of Commercial Broiler Chicken. *Asian Journal of Dairy and Food Research* **40**(3): 337–40.

AOAC. Association of Official Analytical Chemists. *Official Methods of Analysis* (20th Ed.). Gaitherburg, Madison, USA. 2005.

Apajalahti J and Vienola K. 2016. Interaction between chicken intestinal microbiota and protein digestion. *Animal Feed Science and Technology* **221**: 323–30.

Babcock B A, Hays D J and Lawrence J D. 2008. Using Distillers Grains in the U.S. and international livestock and poultry industry. Midwest Agribusiness Trade Research and Information Center, Firstedition (Ames, Iowa, USA).

Bhunia T, Roy B and Das T K. 2023. Growth performance of broiler chicken fed diet with single cell protein. *Indian Journal of Animal Sciences* **93**(5): 501–04.

BIS. 1992. Bureau of Indian Standards: Methods of tests for animal feeds and feeding stuffs: Part II- minerals and trace elements. Manakbhavan, 9 Bahadur Shah Zafar Marg, New delhi-110002.

BIS. 2007. Bureau of Indian Standards: Poultry Feed Specification, 5th revision. ManakBhawan, 9 Bahadur Shah Zafar Marg, New Delhi.

Blair R. 2008. Nutrition and feeding of organic poultry. Cabi Series, CABI, Wallingford, UK.

Cha J Y, Flores, R A and Park H. 2000. Reduction of carotenoids in corn gluten meal with soy flour. *Transcription of the ASAE* **43**: 1169–74.

Dinani O P, Tyagi P K, Mandal A B, Tyagi P K, Singh M, Wani M A and Popat D S. 2018. Effect of feeding rice gluten meal on gut health, immunity and intestinal histomorphometry in broilers. *Bulletin of Environment, Pharmacology and Life Sciences* **7**(5): 49–54.

Duncan D B. 1955. Multiple range and multiple F-tests. Biometrics, 11: 1–42.

Giannenas I, Bonos E, Anestis V, Filioussis G, Papanastasiou D K, Bartzanas T, Apaioannou N, Tzora A and Skoufos I. 2017. Effects of protease addition and replacement of soybean meal by corn gluten meal on the growth of broilers and on the environmental performances of a broiler production system in greece. *PLoS One* 12(1): e0169511.

Heuzé V, Tran G and Sauvant D. 2015.Corn gluten meal. A programme by INRA, CIRAD, AFZ and FAO: Feedipedia; http://www.feedipedia.org/node/715.s

Hu R, Dunmire K M, Truelock C N, Paulk C B, Aldrich G and Li Y. 2020. Antioxidant performances of corn gluten meal and DDGS protein hydrolysates in food, pet food, and feed systems. Journal of Agriculture and Food Research **2**: 100030. https://doi.org/10.1016/j.jafr.2020.100030

Kang D R, Belal S A, Tian W, Park B Y, Choe H S, and Shim K S. 2019. Effect of dietary gluten content on small intestinal inflammatory response of broilers. *European Poultry Science* **83**: 1-9. https://doi.org/10.1399/eps.2019.285

Kang D, Shin D, Choe H, Hwang D, Bugenyi AW, Na C S, Lee HK, Heo J and Shim K. 2022. Transcriptome-wide analysis reveals gluten-induced suppression of small intestine development in young chickens. *Journal of Animal Science and Technology* **64**(4):752-769. doi: 10.5187/jast.2022.e42. Epub 2022 Jul 31. PMID: 35969701; PMCID: PMC9353357.

Kaninde S, Ashok A, PremavalliK, Bandeswaran C and Churchil R R. 2023. Effect of rice distiller dried grains with solubles (RDDGS) in commercial broiler chicken ration on carcass traits, chemical composition, and fatty acid profile of meat. *Indian Journal of Animal Sciences* **93**(6): 613–16.

Leeson S and Summers J D. 2005. Ingredient Evaluation and Diet Formulation Page 41 in: Commercial Poultry Nutrition. University Books, Guelph, ON, Canada.

Longo F A, Menten J F M, Pedroso A A, Figueiredo A N, Racanicci A M C and Sorbara J O B. 2007. Performance and carcass composition of broilers fed different carbohydrate and protein sources in the Prestarter phase. *Journal of Applied Poultry Research* **16**(2):171–77.

Luna L G.1968. Manual of histologic staining methods of the Armed Forces Institute of Pathology. 3rd Edition, McGraw-Hill, New York.

Morishita T, Deguchi Y, Yajima M, Sakurai T, Yura T and 1981. Multiple nutritional requirements of lactobacilli: genetic lesion affecting amino acid biosynthetic pathways. *Journal of Bacteriology* **148**:64–71.

Prabakar G, Shanmuganathan S, Sureshkumar R and Gopi M. 2023. Evaluation of lauric acid and L-glutamate individually and in combination as pro-nutrient growth promoters in broiler chickens. *Indian Journal of Animal Sciences* **93**(6): 607–12.

Rathaur A, Rai1 D C, Bhateshwar V and Singh U P. (2022). Effect of dietary supplementation of linseed (*Linumusitatissimum*)on the growth performance and lipid profile of broiler chickens. *Indian Journal of Animal Sciences* **92**(8): 1024–26.

Sasse C E and Baker D H. 1973. Availability of sulphur amino acids in corn and corn gluten meal for growing chicks. *Journal of Animal Science* **37**:1351–55.

Shariat Z, Pourreza J. and Faghani M. 2015. Effect of inclusion of different levels of liquid corn gluten on performance, carcass characteristics and blood parameters of broiler chickens. *Indian Journal of Fundamental and Applied Life Science* **5**: 2843–49.

SPSS-20. 2011. IBM Corp. IBM SPSS Statistics for Windows, version 20.0. Armonk, NY: IBM corp.

Vasal S K. 2000. The quality protein maize story. *Food and Nutrition Bulletin* **21**: 445–450. doi:10.1177/156482650002100420.

Waldroup P W, Kersey J H and Fritts C A. 2002. Influence of branched chain amino acid balance in broiler diets. *Journal of Poultry Science* **1**(5): 136–44.

Wang Y, Liuxiaolan X L, Jin L, Wen Q, Zhang Y, Narasimha K, Yan E, Wang C and Zheng Y. 2018. Effects of fermented corn gluten meal on growth performance, serum parameters, intestinal morphology, and immunity performance of three-yellow broilers. *Canadian Journal of Animal Science* **99**(2): 408–17.

Wani M, Tyagi P K, Tyagi P K, Sheikh S A, Dinani O P, Hazarika R, Bhanja S K and Mandal A B. 2017. Effect of rice gluten meal as protein source in the diet of broiler chicken: immunity, gut microbial count, haematology and serum biochemical parameters. *Indian Journal of Poultry Science* **52**(3): 277–82.